HUC 07110005 – North Fork Salt
Water body ID: 3960 (formerly 0115U-01)
Pollutant(s): Unknown

Revised
Total Maximum Daily Load
for
Bear Creek
Adair County, MO

Impairment: Unknown

Submitted: January 27, 2020 / Revised April 2020
Approved: July 2, 2020

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Load (TMDL) for Bear Creek
Pollutant: Unknown

Name: Bear Creek

Location: Adair County near Kirksville

8-digit Hydrologic Unit Code (HUC):[1]
07110005 – North Fork Salt

12-digit HUC Subwatersheds:
071100050108 – Upper Bear Creek

Water Body Identification Number (WBID) and Hydrologic Class:[2]
WBID 3960[3] (0115U-01)[4] – Class C

Designated Uses:[5]
Irrigation
Livestock and wildlife protection
Warm water habitat
Human health protection
Whole body contact recreation category B
Secondary contact recreation

Impaired Use:
Warm water habitat[6]

Pollutant Identified on the 2008 303(d) List:
Unknown

Identified Source on the 2008 303(d) List:
Unknown

Length and Location of Impaired Segment:
8.43 miles from Section 08, Township 61N, Range 14W to south Kirksville in Section 22, Township 62N, Range 15W.

---

[1] The U.S. Geological Survey uses a nationwide system based on surface hydrologic features to delineate watersheds. This system divides the country into 2,270 8-digit hydrologic units (USGS and NRCS 2013).

[2] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life.

[3] 10 CSR 20-7.031(1)(Q) defines the Missouri Use Designation Dataset (MUDD) which documents the names and locations of the state's rivers, streams, lakes, and reservoirs which have been assigned designated uses. The MUDD includes rivers, streams, lakes, and reservoirs that were not assigned designated uses or WBIDs prior to November 6, 2013, and that are included within the 100,000-scale (100k) extent of the National Hydrography Dataset (NHD) in the state. The MUDD streams are listed at the top of Table H as 100k Extent-Remaining Streams are Class C (10 CSR 20-7.031(1)(F)), and have all been assigned WBID 3960.

[4] Bear Creek was listed on the 1994/1996 Missouri 303(d) List of impaired waters but was not assigned a WBID. In 1998, Bear Creek was not included on the 303(d) List. Bear Creek was listed on the 2002 303(d) List once again but was not assigned a WBID. On the 2004/2006 list, Bear Creek was assigned a WBID of 0115U (based upon the WBID of the downstream segment of Bear Creek which is WBID 0115), and in the 2008 303(d) List it was assigned WBID 0115U-01.

[5] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

[6] Original impairment listing in 2008 was based on violations of Missouri's general criteria since no uses were designated to this stream at that time

Table of Contents

Figures

Tables

1. Introduction

The Missouri Department of Natural Resources in accordance with Section 303(d) of the federal Clean Water Act is establishing this total maximum daily load (TMDL) to address “unknown” pollutants in Bear Creek near Kirksville in Adair County. This Revised TMDL supersedes the TMDL approved by the U.S. Environmental Protection Agency (EPA) on December 23, 2010, that was established to meet the milestones of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001. Bear Creek was first listed on the 1994/1996 Missouri 303(d) List of impaired waters and was listed again on the 2002 303(d) List[7] due to reduced numbers of riffle fish species determined by a fish inventory conducted by the Missouri Department of Conservation in 2001. No specific designated uses were assigned to this segment of Bear Creek at the time of the development of the 2010 TMDL, therefore the 2010 TMDL was written to address violations of Missouri’s general water quality criteria in 10 CSR 20-7.031(4) that are applicable to all waters of the state. Bear Creek has since been added to the Missouri Use Designation Dataset (MUDD) in Missouri Water Quality Standards, and designated uses and specific numeric criteria now apply.

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters not meeting applicable water quality standards. Missouri’s Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7.031 consist of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. The purpose of a TMDL is to determine the loading capacity of a specific pollutant that a water body can assimilate without exceeding the applicable water quality standards for that water body. The TMDL process quantitatively assesses impairment factors so that water quality-based controls can be established to reduce pollutant loading and to restore and protect the quality of Missouri’s water resources. Based on the relationship between pollutant sources and in-stream water quality conditions, a TMDL is the sum of a wasteload allocation and a load allocation (40 CFR 130.2) with a margin of safety (federal Clean Water Act section 303(d)(1)(C)). The wasteload allocation is the fraction of the loading capacity apportioned to existing or future point sources. The load allocation is the fraction of the loading capacity apportioned to existing or future nonpoint sources and natural background. The margin of safety is a portion of the TMDL that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality (40 CFR 130.7), any uncertainty associated with the model assumptions, and data inadequacies.

2. Rationale for Revision

Since the original listing of Bear Creek, the Kirksville Wastewater Treatment Facility, which discharges effluent to the impaired segment of Bear Creek, has substantially expanded and has engineered improvements in treatment plant operation. In addition, greater understanding of the characteristics of Bear Creek and the surrounding watershed warrant a reevaluation of the impairment and the conditions for which water quality standards can be attained. Advances in geographical information systems (GIS) and additional information sources that have become available in the decade since the development of the original TMDL provide an opportunity to make

[7] The Department maintains current and past 303(d) lists and corresponding assessment worksheets online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

such a reevaluation. No new water quality data from Bear Creek have been collected since 2009; however, review of the 2010 QUAL2K model indicates the need for significant changes in some modeling assumptions and data inputs to create a better representation of actual stream hydrology and improved predictive ability.

The 2010 Bear Creek TMDL established total nitrogen (TN) and total phosphorus (TP) wasteload and load allocations based on EPA Level III Ecoregion 40 criteria (USEPA 2000). However, the Ecoregion 40 nutrient criteria targets were developed based on streams in pristine or near-pristine environments and may not be representative of more localized reference conditions. The targets are not tied to specific biological conditions or Missouri's minimum dissolved oxygen criterion. Additionally, these federally recommended nutrient criteria use a statistic-based, distributional approach that has little or no linkage to biological "cause and effect" responses or ecologically significant thresholds, and merely represents an administrative water quality protection policy that guides EPA's clean water programs. For these reasons, these targets may not be appropriate metrics for use as wasteload allocations for point source discharge from wastewater treatment facilities. The Department has revised the Bear Creek TMDL so that pollutant targets are proportionate to the existing land uses and geomorphic characteristics of Bear Creek and its contributing watershed. The pollutant targets in the revised TMDL have been established such that the 5.0 milligrams per liter (mg/L) minimum criterion for dissolved oxygen will be achieved, and will ensure conditions are consistent with Missouri's general narrative water quality criteria. Such targets will result in restoration of the protection of warm water habitat (aquatic life) designated use in Bear Creek and will be protective of downstream uses.

The targets and information provided in this revised TMDL replace those found in the 2010 TMDL. The ultimate endpoint for this revised TMDL will be to meet Missouri Water Quality Standards through attainment of the minimum dissolved oxygen criterion for the protection of aquatic life in warm water habitats of 5.0 mg/L and general criteria associated with excessive sedimentation. Compliance with these criteria will be determined in accordance with Department assessment procedures for federal Clean Water Act sections 305(b) and 303(d) reporting. All pollutant reductions necessary to achieve the TMDL targets calculated in this revised TMDL shall be implemented until such a point that water quality standards are attained. If all point source and nonpoint source pollutant targets are achieved, but water quality standards are not attained, then additional monitoring will be scheduled and the TMDL may be further revised.

3. Water Body and Watershed Descriptions

The Bear Creek watershed is located in northeast Missouri within the North Fork Salt subbasin, which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 07110005. The impaired segment of Bear Creek is in the upper 25.5 square miles of the Upper Bear Creek 12-digit HUC 071100050108, which receives runoff from the southern half of the City of Kirksville, effluent from the Kirksville Wastewater Treatment Facility, and substantial runoff from extensive hay and pasture lands in the contributing watershed. The headwaters of Bear Creek originate in southern Kirksville. The impaired segment of Bear Creek flows for 8.43 miles, and the remainder of Bear Creek flows through the Middle and Lower Bear Creek 12-digit HUCs, 071100050109 and 071100050110 respectively, for an additional 36 miles to North Fork Salt River. The location of the impaired segment of Bear Creek is presented in Figure 1.

The upper segment of Bear Creek, which is the subject of this TMDL, was listed on the 1994/1996 and 2002 Missouri 303(d) Lists of impaired waters but was not listed in Missouri Water Quality Standards at that time nor was it assigned a water body identification (WBID) number. On the 2004/2006 303(d) List, although still not having designated uses, the impaired segment of Bear Creek was assigned a WBID of 0115U, and on the 2008 303(d) List it was assigned WBID 0115U-01. Incorporation of the upper segment of Bear Creek into Missouri Water Quality Standards, and designation of beneficial uses for the stream segment, occurred through water quality standard revisions published on January 29, 2014, and recorded in the Missouri Use Designation Dataset (MUDD). The MUDD is defined in 10 CSR 20-7.031(1)(Q) and documents the names and locations of the state's water bodies which have been assigned designated uses. In addition to those waters identified in Tables G and H of 10 CSR 20-7.031, the MUDD identifies water bodies included within the 100,000-scale (100k) extent of the National Hydrography Dataset (NHD) that did not have designated uses prior to January 29, 2014. These additional streams, which include the impaired segment of Bear Creek, have collectively been assigned WBID 3960.

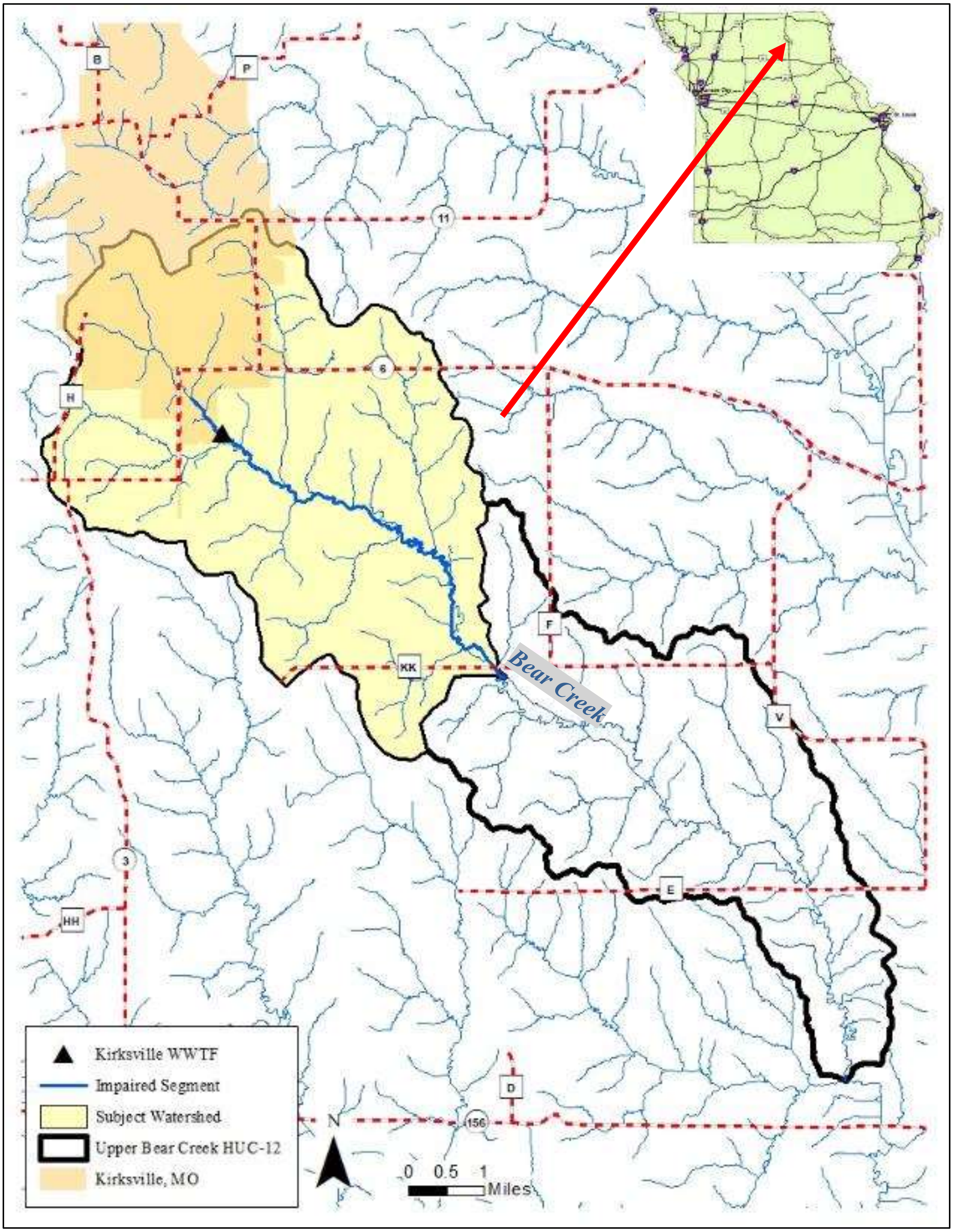

Figure 1. Upper Bear Creek Watershed and Location of the Impaired Segment

3.1 Geology, Physiography and Soils

The Bear Creek watershed is located within the Cuivre/Salt ecological drainage unit, which lies mostly in northeastern Missouri. Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). This drainage unit consists of tills (sand, silt, and clays) and the west and southwest portions where the impaired segment is located is within a distinct area of the Claypan Region. Small streams tend to be intermittent with low base flows due to a lack of karst features. Surface water is the dominant recharge making the streams turbid with fine silts and sands (MoRAP 2005).

The Bear Creek watershed is also located in the Claypan Prairie Level IV ecoregion. Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are further defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H). The Claypan Prairie ecoregion has gentle rolling hills and is more level than its surrounding ecoregions. Other key characteristics of the Claypan Prairie ecoregion are the well-developed soils on glacial till and perennial streams that flow in a west to east direction into the Mississippi River (Chapman et al. 2002).

As presented in Table 1, soils in the watershed draining to the impaired segment of Bear Creek consist of silt loam, clay loam, and silty clay loam. Although soils in the watershed are varied, they can be categorized based on similar runoff potentials into hydrologic soil groups. A hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface, which in turn may affect the potential amount of water entering the stream as runoff (NRCS 2009). Group A represents soils with the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and the highest potential for runoff. Group C soils have a low-moderate rate of infiltration and a moderate-high potential for runoff. Dual soil groups (e.g., B/D) account for the presence of a high water table by providing both the drained and undrained condition of the soil.[8] Table 2 provides a summary of the hydrologic soils groups in the subject watershed and Figure 2 shows their distribution. There are no Group A soils in the subject watershed.

[8] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

Table 1. Soil Types In and Adjacent to Bear Creek (NRCS 2017)

Soil Type	Description	Characteristics	Hydrologic Soil Group	% of Watershed
Streambed				
Adco silt loam	0-3% slopes, occasionally flooded	Somewhat poorly drained soils on Claypan Summit Prairie	C/D	13.0%
Dockery and Tice silt loams		Somewhat poorly drained soils on Loamy Floodplain Forest	C	0.4%
Putnam silt loam		Poorly drained hydric soils on Claypan Summit Prairie	D	0.9%
Vesser silt loam		Poorly drained hydric soils on Wet Upland Drainageway Prairie	C/D	8.7%
Adjacent Slopes				
Armstrong loam	5-9% slopes, eroded	Somewhat poorly drained soils on Till Upland Savanna	D	35.2%
Armstrong clay loam	9-14% slopes, moderately eroded			5.9%
Bevier silty clay loam	3-8% slopes	Somewhat poorly drained soils on Loess Upland Prairie	C/D	0.7%
Gara fine sandy loam	14-20% slopes, eroded	Moderately well drained soils on Till Backslope Savanna	B/D	10.7%
Gara loam	9-14% slopes, moderately eroded	Well-drained soils on Till Upland Savanna	C	7.2%
Gorin-Winnegan complex	5-14% slopes, eroded	Somewhat poorly drained soils on Loess Upland Woodland	C	0.2%
Leonard silt loam	1-6% slopes, eroded	Poorly drained soils on Loess Upland Prairie	C/D	8.2%
Purdin clay loam	14-20% slopes, eroded	Moderately well drained soils on Till Backslope Savanna	D	7.8%
	20-35% slopes, eroded			0.1%
Winnegan loam	20-35% slopes	Moderately well drained on Till Protected Backslope forest	D	1.0%

Table 2. Summary of Hydrologic Soil Groups in the Subject Watershed of Bear Creek (NRCS 2009)

Hydrologic Soil Group	Area (mi^2)	Area (%)
B/D	2.73	10.73%
C	1.95	7.66%
C/D	13.45	52.85%
D	7.32	28.76%
Total	25.45	100.00%

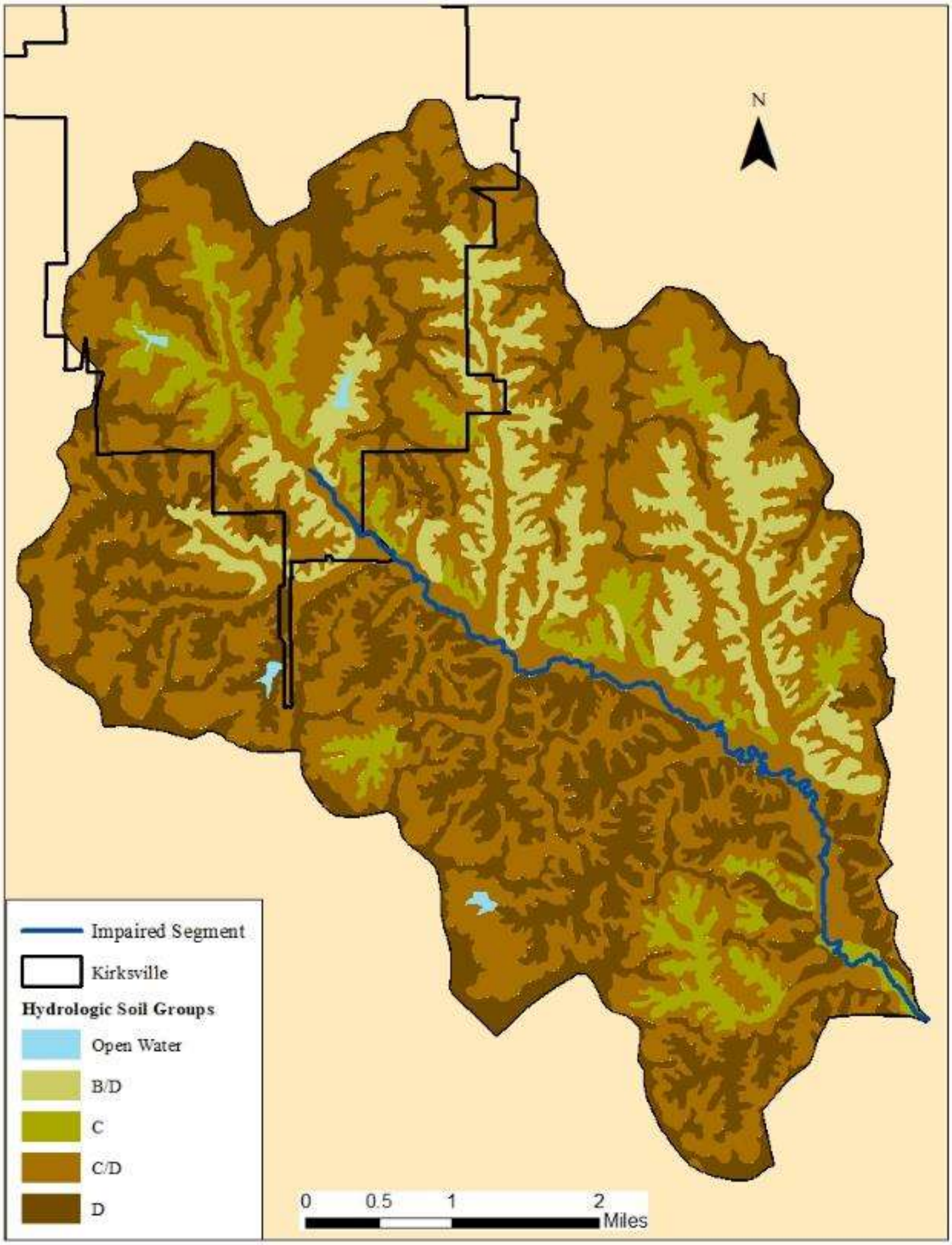

Figure 2. Hydrologic Soil Groups in the Subject Watershed of Bear Creek

3.2 Climate

Climate normals are 30-year averages of climatological variables, including temperature and precipitation, produced by the National Centers for Environmental Information every 10 years (NOAA 2010). The monthly precipitation and temperature normals calculated using daily weather data from the Kirksville station (No. 234544) are representative of the climatic conditions in the watershed. Of the various climatic factors, precipitation is especially important as it is related to stream flow and runoff events that can influence the transport of pollutants from nonpoint sources into streams. Table 3 and Figures 3 and 4 compare 2009 temperature and precipitation data with the 30-year climate normal rainfall and temperature data observed at Station No. 234544 in Kirksville. The U.S. Drought Monitor (University of Nebraska 2019) determined that the North Fork Salt River HUC-8 was not dry in 2009.

Table 3. Comparison of Climate Normals and 2009 Data at the Kirksville Weather Station No. 234544 (NOAA 2010)

	Precipitation (inches)		Max. Temp. (ºF)		Min. Temp. (ºF)	
Month	**Normal**	**2009**	**Normal**	**2009**	**Normal**	**2009**
January	1.29	0.05	33.4	30.3	14.7	9.6
February	1.65	1.63	38.5	42.7	18.5	19.7
March	2.52	7.16	50.4	52.3	28.7	29.4
April	3.68	4.69	62.2	58.6	39.4	38.8
May	5.38	6.71	71.9	72.1	50.6	50.0
June	5.30	7.78	80.9	81.1	60.5	62.1
July	5.17	3.17	85.5	80.0	65.1	60.3
August	4.05	8.05	84.1	80.2	62.9	60.3
September	4.06	4.44	76.4	75.0	53.4	52.4
October	3.32	10.18	64.2	55.3	42.2	38.9
November	2.63	2.9	50.1	57.1	30.2	37.0
December	1.62	1.14	36.6	32.9	18.7	17.5
	Total		**Average**		**Average**	
	40.67	**57.9**	**61.18**	**59.8**	**40.41**	**39.7**

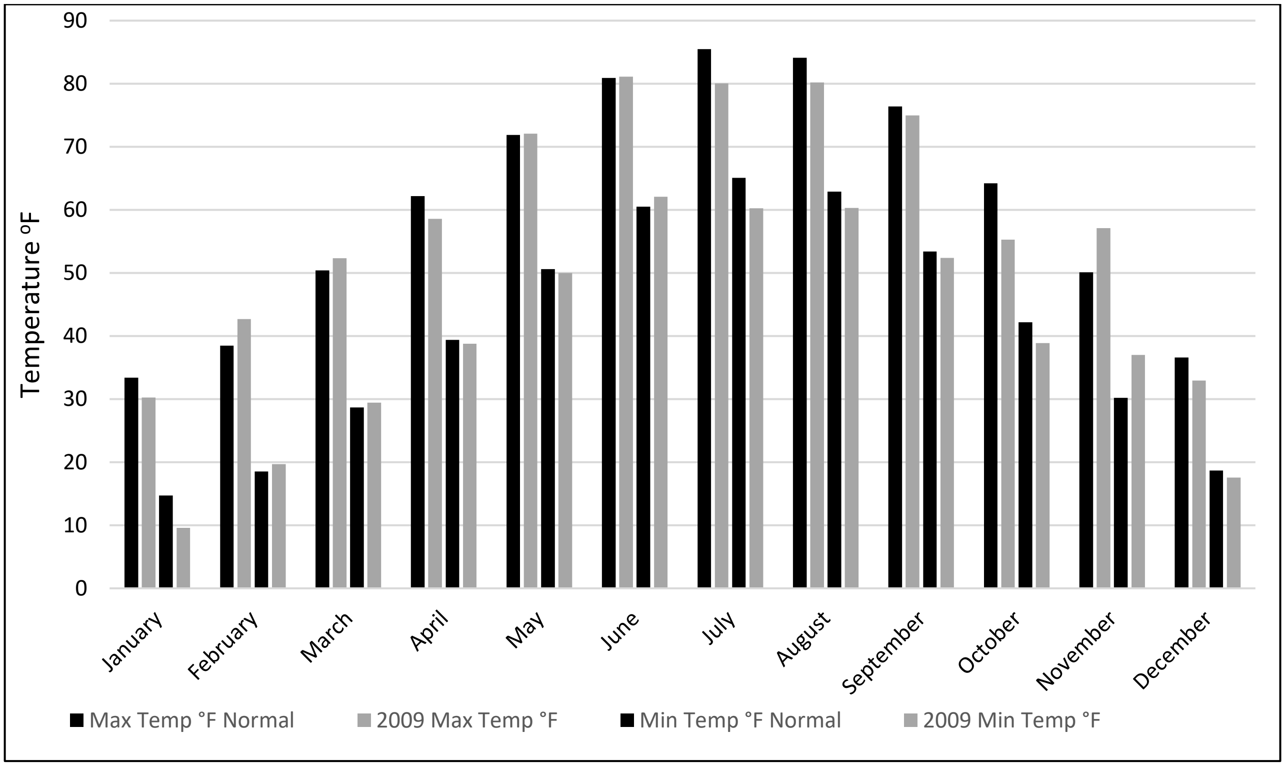

Figure 3. Comparison of Climate Normal and 2009 Average Monthly Minimum and Maximum Temperatures

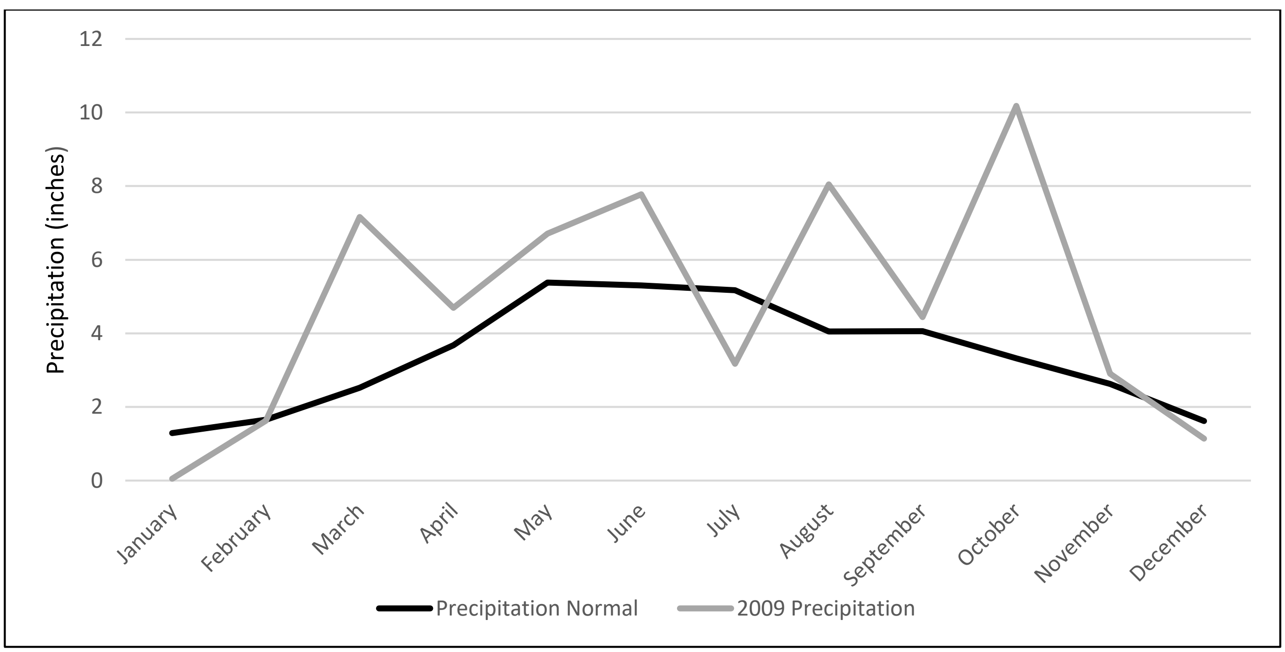

Figure 4. Comparison of Climate Normal and 2009 Average Monthly Precipitation

3.3 Population

The population estimates presented in Table 4 were derived using GIS software and superimposing the watershed boundary over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within a watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, then the population of the entire block was excluded. Using a similar method, the municipal population was estimated by superimposing municipal areas over the map of census blocks.

Table 4. Population Estimates for the Subject Watershed of Bear Creek

Municipal Population			Rural Population			Total Population		
1990	**2000**	**2010**	**1990**	**2000**	**2010**	**1990**	**2000**	**2010**
8,672	8,384	8,695	636	606	632	9,308	8,990	9,327

The U.S. Census Bureau estimated the population of the City of Kirksville in 2010 to be 17,505 people. Of the 14.4 square mile municipal area, 5.9 square miles (41 percent) are within the subject watershed. In 2010, approximately 50 percent of the City of Kirksville population resided in the southern portion of the city located within the subject watershed, and only 0.04 percent of the population in the watershed resided in rural areas.

In 2013, EPA completed a separate population analysis based on 12-digit HUC subwatersheds for purposes unrelated to this TMDL. They used demographic and census block data, and a web-based tool called EJSCREEN to determine areas of Missouri having potential Environmental Justice concerns. EPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Environmental Justice communities may qualify for financial and strategic assistance for addressing environmental and public health issues. From this analysis, EPA determined that the Upper Bear Creek watershed has some potential environmental justice concerns (less than 5 percent area).

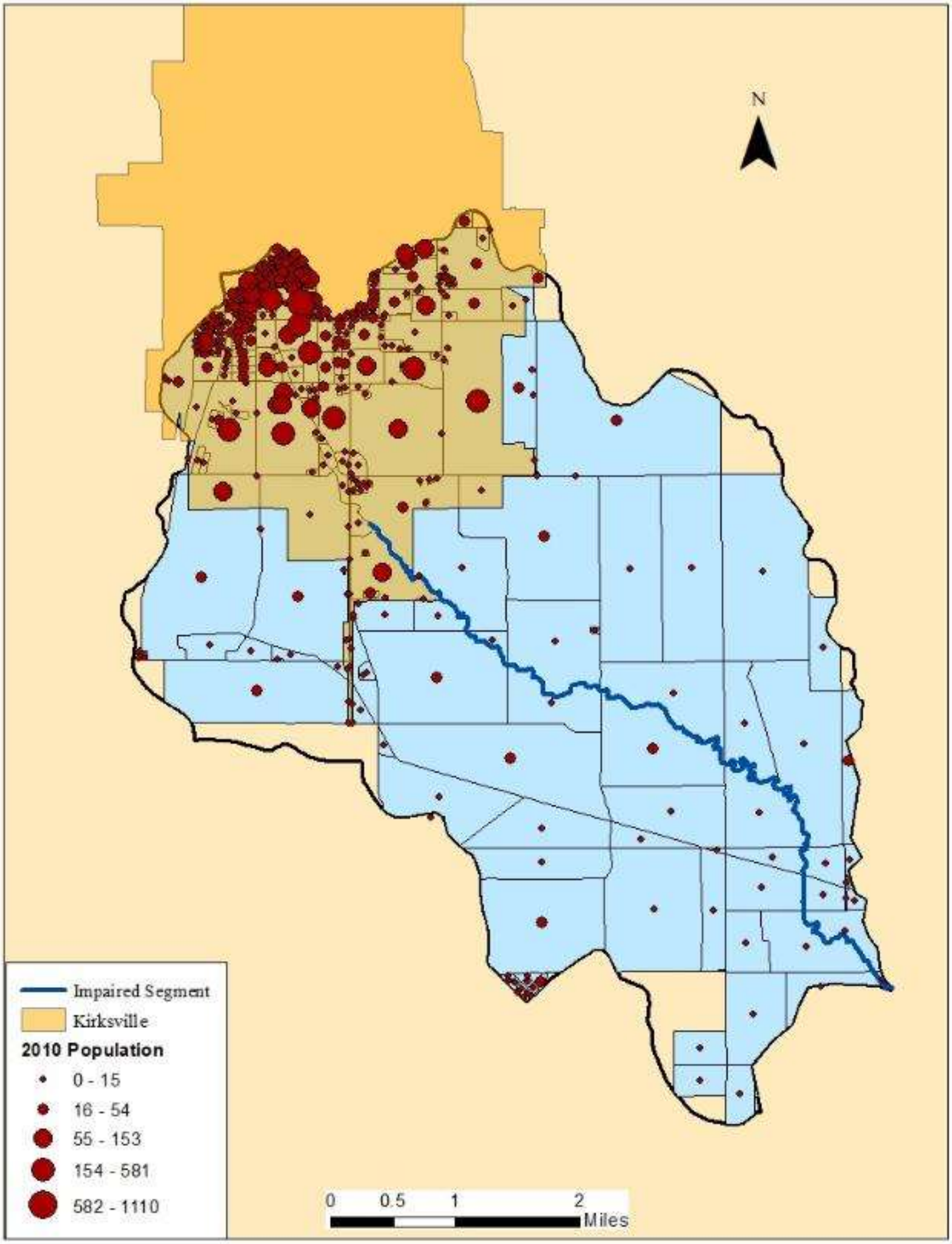

Figure 5. Population Density in the Subject Watershed of Bear Creek

3.4 Land Cover

A land cover analysis was completed using the 2011 National Land Cover Database published by the U.S. Geological Survey (USGS) (Homer et al. 2015). Land cover calculations are summarized in Table 5. The total amount of developed area in the watershed is approximately 16 percent. Impervious surfaces associated with the developed land cover types ranges from less than 20 percent to greater than 79 percent. Stream degradation associated with impervious surfaces has been shown to first occur at about 10 percent impervious and increases in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). The predominance of hay and pasture lands (58.6 percent) coupled with the predominance of soils with high runoff potential (Table 2) increase the likelihood of sediment or nutrient transport from nonpoint sources (i.e., overland flow) into Bear Creek. Figure 6 depicts the distribution of the land coverage throughout the subject watershed.

Table 5. Land Cover in the Subject Watershed of Bear Creek

Land Cover	Area (mi^2)	Percent
Barren Land	0.009	0.04%
Developed, High Intensity	0.088	0.35%
Developed, Medium Intensity	0.488	1.92%
Developed, Low Intensity	1.62	6.36%
Developed, Open Space	1.85	7.27%
Cultivated Crops	2.11	8.29%
Hay and Pasture	14.92	58.60%
Forest	3.51	13.79%
Shrub and Herbaceous	0.535	2.10%
Wetlands	0.136	0.53%
Open Water	0.196	0.77%
Total	25.46	100%

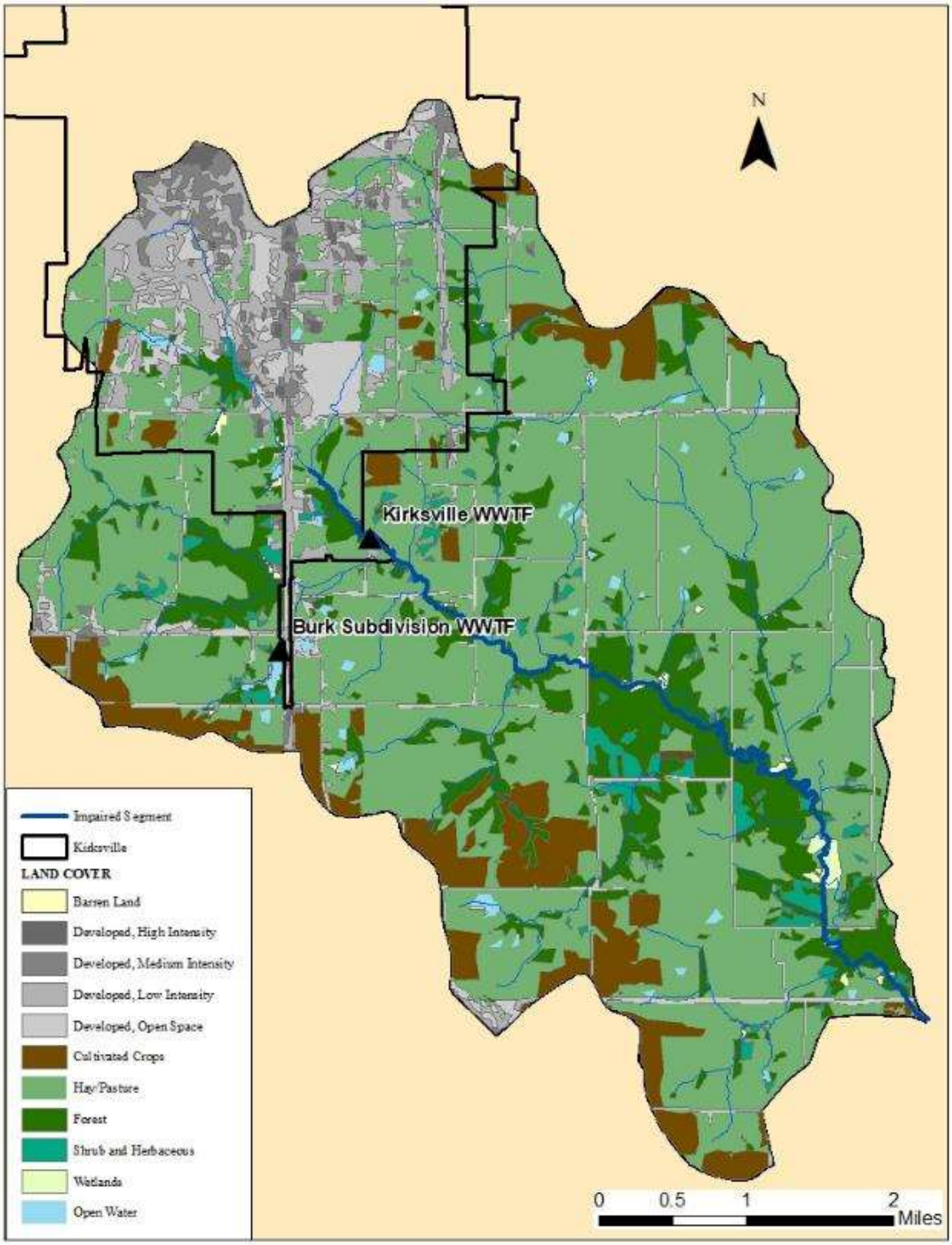

Figure 6. Land Cover in the Subject Watershed of Bear Creek

4. Applicable Water Quality Standards

The purpose of developing a TMDL is to identify the maximum pollutant loading that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy.

Per federal regulations at 40 CFR §131.10, the designated uses and criteria to protect those uses assigned to a water body shall provide for the attainment and maintenance of the water quality standards of downstream waters. The components of Missouri's Water Quality Standards discussed in this section meet these requirements and are approved by the EPA. It is not the purview of a TMDL to revise existing water quality standards. In the event that future water quality monitoring demonstrates that water quality standards are not protective of downstream uses, the federal Clean Water Act provides means to address the situation. Such means are described in the EPA's Water Quality Standards Handbook.[9]

4.1 Designated Uses

Designated uses are the uses for a water body defined in the Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(C) and assigned per 10 CSR 20-7.031(2) and Table H. These uses must be maintained in accordance with the federal Clean Water Act.

The impaired segment of Bear Creek was assigned designated uses on January 29, 2014, when the Department developed the Missouri Use Designation Dataset (MUDD) which assigns designated uses to the state's rivers, streams, lakes, and reservoirs that are included within the 100k extent of the NHD (10 CSR 20-7.031(1)(Q)). Bear Creek, and other streams collectively identified as WBID 3960, are listed at the top of Table H as 100k Extent-Remaining Streams and have been assigned the following designated uses as described at 10 CSR 20-7.031(2)(E):

- Irrigation;
- Livestock and wildlife protection;
- Human health protection;
- Warm water habitat;
- Whole body contact recreation Category B;
- Secondary contact recreation.

Bear Creek is impaired due to nonattainment of the warm water habitat aquatic life use.

4.2 Water Quality Criteria

Water quality criteria are limits on certain chemicals or conditions in a water body to protect particular designated uses. Water quality criteria can be expressed as specific numeric criteria or as general narrative statements. Missouri 10 CSR 20-7.031(4) and (5) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031 Tables G (Lakes) and H (Streams). Although no specific pollutant has been identified as being the primary cause of impairment in Bear Creek, available data and field

[9] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

observations note water quality violations of general criteria associated with sediment loading as well as violations of the specific criterion for minimum dissolved oxygen concentrations in warm water habitats.

Excessive sediment deposition, either organic or inorganic, that results in bottom deposits that harm aquatic life or otherwise prevent the full maintenance of beneficial uses are violations of the general criteria specified at 10 CSR 20-7.031(4)(A) and (C). For streams designated for the protection of aquatic life associated with the warm water habitat use, Table A1 of 10 CSR 20-7.031 specifies a minimum criterion of 5.0 mg/L of dissolved oxygen.

The ultimate endpoint for this revised TMDL will be to meet Missouri Water Quality Standards through attainment of the minimum dissolved oxygen criterion of 5 mg/L and attainment of general criteria associated with waters free from excessive sedimentation. Compliance with these criteria will be determined in accordance with Department assessment procedures for federal Clean Water Act sections 305(b) and 303(d) reporting.

4.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing in-stream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goal for Bear Creek is to restore water quality to levels that meet the water quality standards.

5. Defining the Problem

In 2001 a fishery study, in which the Missouri Department of Conservation (MDC) compared fish species in Bear Creek to those in North Fork Salt River, found that there were reduced numbers of riffle fish species in Bear Creek (MDC 2001). This finding prompted the Department to include Bear Creek on the 2002 Missouri 303(d) List of impaired waters.

In 2009, monitoring was conducted on Bear Creek during summer low-flow conditions (July and August). Sample points are presented in Figure 7.[10] Stream data are typically collected in July and August during critical low flow conditions because this is when water temperatures and in-stream productivity are highest. Sampling during the critical condition is intended to capture the lowest annual dissolved oxygen concentrations in order to protect the designated uses under all conditions. As presented in Table 6 and Figure 8, the water quality data collected in 2009 showed that Bear Creek did not meet the minimum water quality criterion of 5.0 mg/L dissolved oxygen in seven out of 55 (12.7 percent) of the 2009 samples. Low dissolved oxygen affects biological activity and is a likely contributor for reduced numbers of riffle fish species in Bear Creek.

In addition, benthic macroinvertebrate studies found that Bear Creek was only partially supporting taxa richness and diversity at 3 out of 7 sample sites. Low fish and macroinvertebrate diversity can result from both low dissolved oxygen and poor quality substrate. The predominance of fine-grained erodible soils (silt and loam) in the streambed, and high runoff potential for soils adjacent to Bear Creek, indicates that when precipitation is high Bear Creek will have high turbidity due to the presence of suspended solids in the stream. When the fine sediment settles, it eliminates the interstitial habitat that would be present between gravel and sand particles. In addition to low dissolved oxygen, these sedimentation factors also likely contribute to low fish and macroinvertebrate diversity.

[10] Data were not collected at sample point 3, so it has been omitted from the figure and analysis.

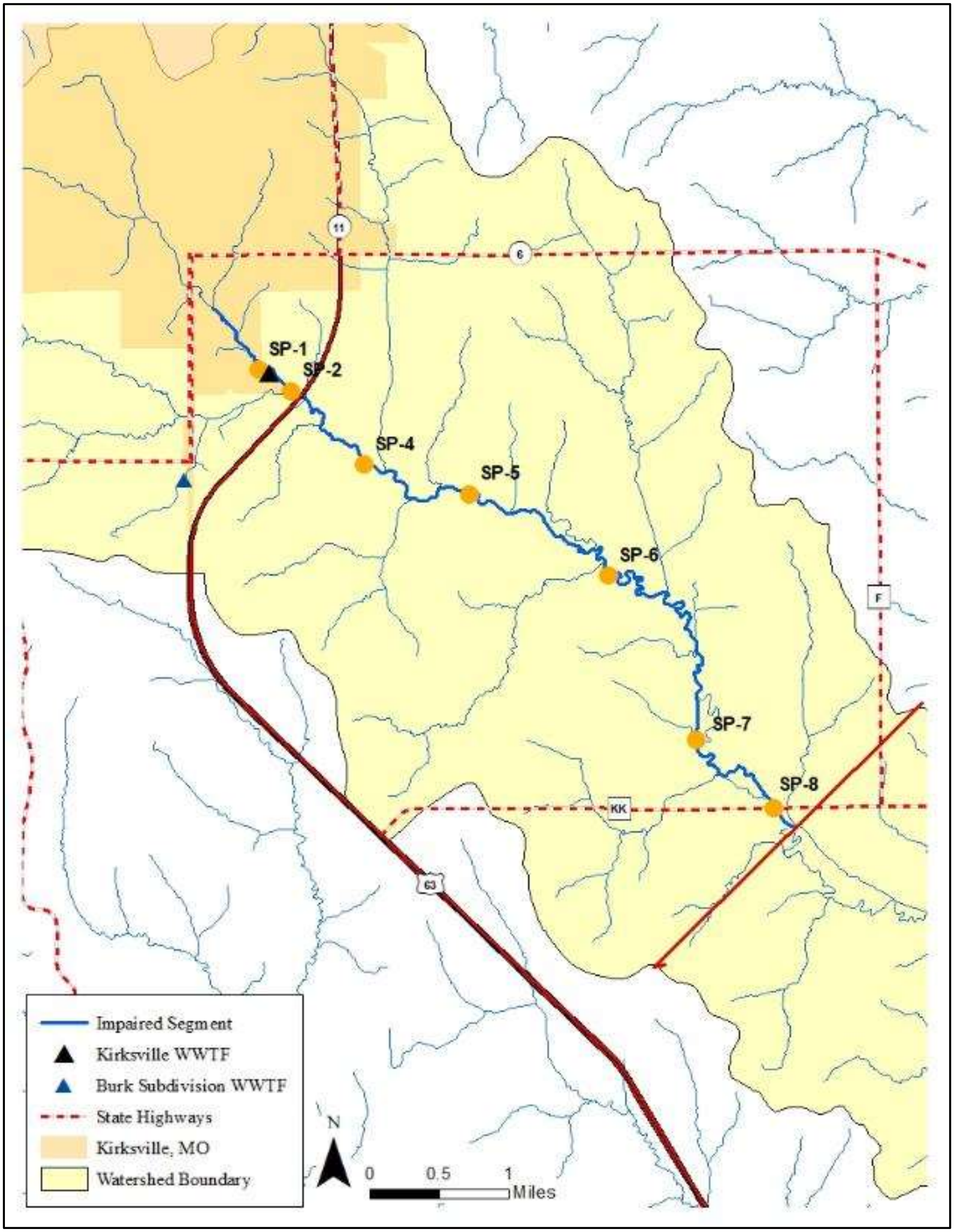

Figure 7. Sample Point Locations

Table 6. 2009 Dissolved Oxygen Concentrations in the Impaired Segment of Bear Creek

Sample Date	SP-1		SP-2		SP-4		SP-5		SP-6		SP-7		SP-8	
	Time	DO mg/L	Time	DO mg/L	Time	DO mg/L	Time	DO mg/L	Time	DO mg/L	Time	DO mg/L	Time	DO mg/L
7/14/2009	6:15	3.80	6:50	6.16	5:40	5.07	5:13	3.33	6:15	4.20	5:45	5.52	5:05	5.05
7/14/2009	12:55	5.92	13:50	6.68	12:25	5.59	12:00	4.65	13:15	5.10	12:40	9.13	12:02	7.63
7/15/2009	06:15	3.98	6:50	6.15	5:40	5.77	5:13	5.43	6:15	4.40	5:45	6.09	5:05	6.07
7/15/2009	No data		13:50	7.02	12:25	5.22	12:00	3.13	13:15	7.54	12:40	10.77	12:02	9.97
8/25/2009	8:05	7.80	7:30	9.20	6:50	7.20	5:45	7.00	7:15	9.66	6:40	11.63	5:35	11.96
8/25/2009	14:35	7.80	13:20	6.40	12:45	6.10	12:10	8.42	13:30	8.99	12:50	10.34	12:05	7.80
8/26/2009	6:55	6.00	6:25	7.30	6:00	5.80	5:25	5.30	6:40	7.84	6:00	8.60	5:29	8.50
8/26/2009	14:45	6.40	14:15	9.00	12:35	6.50	12:00	6.10	13:05	8.33	12:35	9.35	12:02	10.03

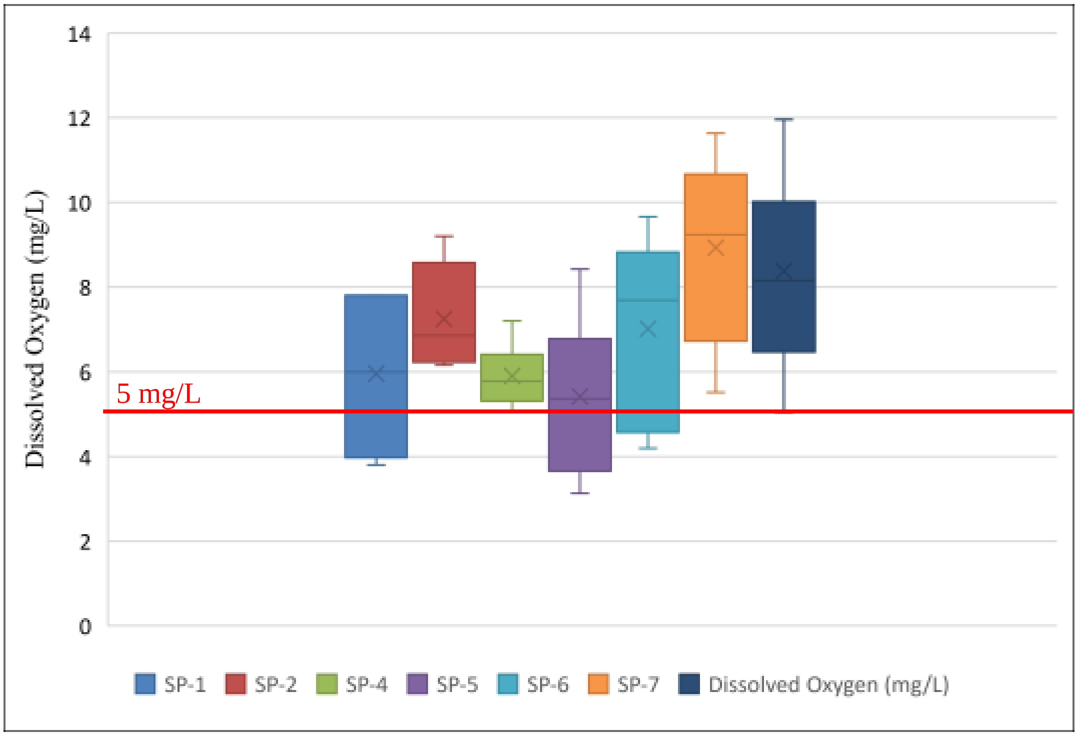

Figure 8. Dissolved Oxygen Concentrations at 2009 Sample Points

Low dissolved oxygen is not a pollutant and cannot be allocated in a TMDL. However, biochemical oxygen demand, which drives in-stream oxygen consumption, is measurable and is representative of both the quantity of organic material in effluent and the concentration of dissolved oxygen in the receiving stream. There is no numeric criterion in the Missouri Water Quality Standards for biochemical oxygen demand, but the Water Quality Standards do establish a minimum daily criterion of 5 mg/L for dissolved oxygen. Since dissolved oxygen cannot be allocated, but does have a numeric criterion, dissolved oxygen concentrations are linked to biochemical oxygen demand.

In-stream dissolved oxygen and biochemical oxygen demand are affected by several factors including water temperature, the amount of decaying matter (i.e., organic material containing nutrients) in the stream, nutrient transport into streams from overland runoff, turbulence at the air-water interface, and the amount of photosynthesis occurring in plants within the stream. Nutrients (i.e., nitrogen and phosphorus) enter streams from wastewater effluent as well as agricultural and urban runoff. Decaying matter can also accumulate on the bottom of a stream and cause sediment oxygen demand. Sediment oxygen demand is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. Most of the sediment oxygen demand at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of ammonia nitrogen (NH_4-N).

Given the relationships between oxygen demand, dissolved oxygen, and biological activity, it is likely that low dissolved oxygen conditions in Bear Creek contribute to the observed decline in fish species and benthic invertebrate health. Habitat degradation due to excessive deposition of sediment has also contributed to the decline in fish and macroinvertebrate populations. Excessive loads of decayable organic matter from sewage effluent and nutrients in urban runoff are likely the main contributors to low dissolved oxygen in Bear Creek because during critical low flows, wastewater effluent and urban irrigation runoff are most, if not all, of the stream flow.

6. Source Inventory and Assessment

Various sources may be contributing pollutant loading to the impaired segment of Bear Creek that impact in-stream dissolved oxygen concentrations and sediment deposition. For this reason, a source inventory and assessment is included in this TMDL report to identify and characterize known, suspected, and potential sources of pollutant loading to Bear Creek. These sources are categorized as being either point (regulated) or nonpoint (unregulated).

6.1 Point Sources

Point sources are defined under Section 502(14) of the federal Clean Water Act and are typically regulated through the Missouri State Operating Permit program.[11] Point sources include any discernible, confined, and discrete conveyance, such as a pipe, ditch, channel, tunnel, or conduit, by which pollutants are transported to a water body. Under this definition, permitted point sources include permitted municipal and domestic wastewater dischargers, site-specific permitted industrial and non-domestic wastewater dischargers, concentrated animal feeding operations (CAFOs), Municipal Separate Storm Sewer System (MS4), and general wastewater and stormwater permitted entities. In addition to these permitted sources, illicit straight pipe discharges, which are illegal and therefore unpermitted, are also point sources. As presented in Figure 9, point sources in the subject watershed of this TMDL include one municipal and one private domestic wastewater treatment facility, one general permit related to swimming pool discharges, and six stormwater permits associated with construction and land disturbance activities. In addition to these permitted activities, stormwater discharges from the City of Kirksville are regulated through a small MS4 general

[11] The Missouri State Operating Permit Program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit. Issued and proposed operating permits are available online at dnr.mo.gov/env/wpp/permits/index.html.

permit. Likewise, stormwater discharges from Highway 63 in Kirksville are regulated through a site-specific MS4 permit issued to the Missouri Department of Transportation (MoDOT).

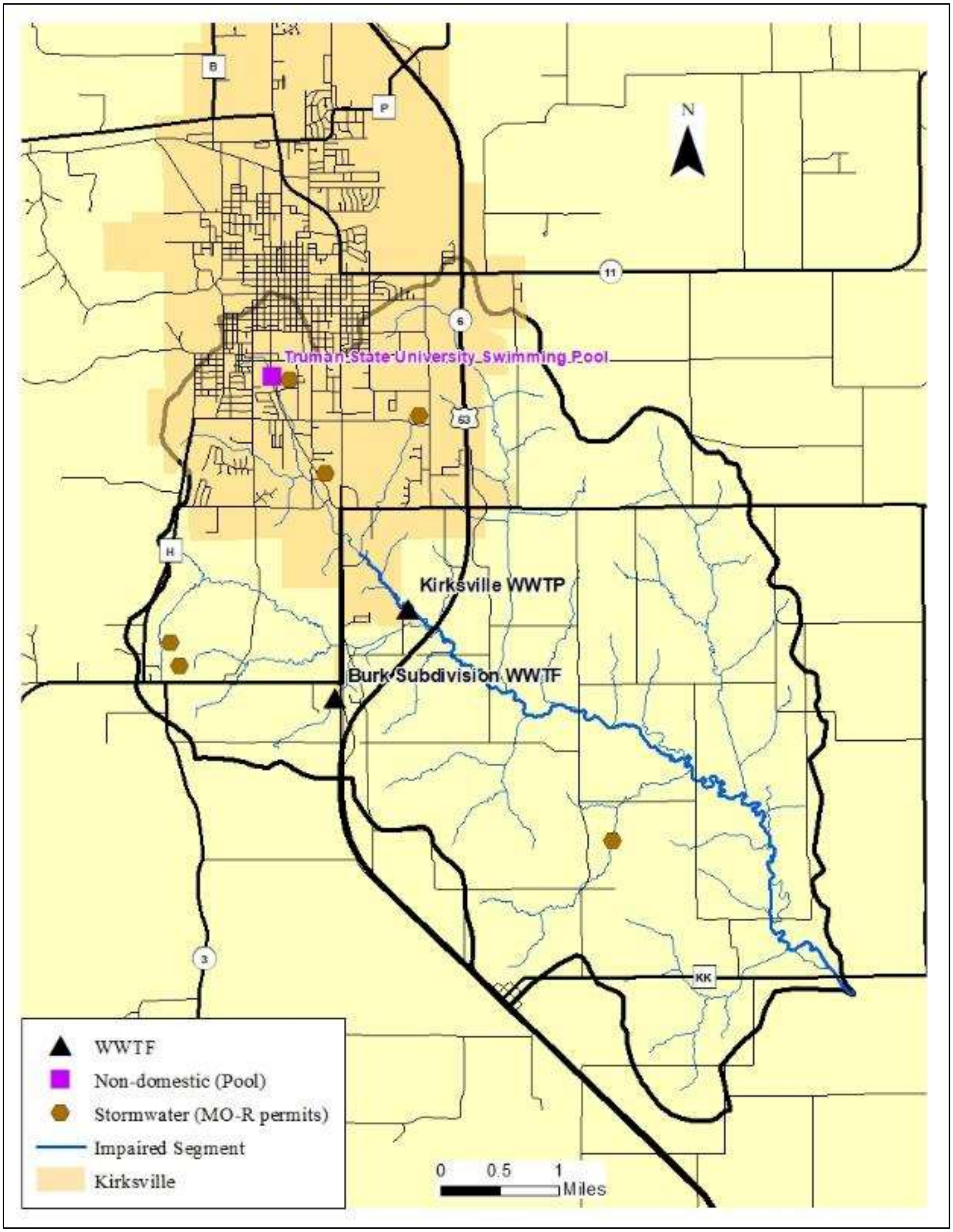

Figure 9. Point Sources in the Subject Watershed of Bear Creek

6.1.1 Municipal and Domestic Wastewater Discharge Permits

Dischargers of domestic wastewater include both publicly owned municipal wastewater treatment facilities and private non-municipal treatment facilities. Domestic wastewater is primarily household waste, including graywater and sewage. Untreated or inadequately treated discharges of domestic wastewater can be significant sources of biochemical oxygen demand, nitrogen, and phosphorus to receiving waters. Influences of pollutant loading from domestic dischargers are typically most evident at low-flow conditions when stormwater influences are lower or nonexistent.

As of June 2019, the Bear Creek watershed contained the publicly owned Kirksville municipal wastewater facility and the private Burk Subdivision non-municipal treatment facility (Table 7). A $20 million upgrade to the Kirksville Wastewater Treatment Facility was completed on October 26, 2017. The facility was expanded from its historic design flow of 3.16 million gallons per day (MGD) to a design flow of 4 MGD with the ability to handle peak flows of 12 MGD. Effluent from the Kirksville Wastewater Treatment Facility provides the majority of the flow in Bear Creek during the low-flow critical condition and is a potential contributor of pollutants that may result in low dissolved oxygen conditions.

As of June 2019, the design flow of the Burk Subdivision Wastewater Treatment Facility was 11,100 gallons per day (GPD), which is 0.28 percent of the Kirksville Wastewater Treatment Facility's design flow of 4.0 MGD. In addition, the Burk Subdivision Wastewater Treatment Facility is 1.5 miles, and two tributaries, upstream of Bear Creek. Based on this information it can be reasonably concluded that the Burk Subdivision Wastewater Treatment Facility does not cause or contribute to the impairment in Bear Creek.

Table 7. Municipal and Domestic Wastewater Dischargers in the Subject Watershed of Bear Cr.

Facility	Permit No.	Design Flow	Expires	Permit Status
Kirksville WWTF	MO-0049506	4 MGD	2/9/2011	Expired
Burk Subdivision WWTF	MO-0107557	11,100 GPD	7/31/2022	Effective

In addition to the direct discharges from domestic wastewater treatment facilities, potential pollutant contributions may also occur from overflows occurring from the adjoining sanitary sewer system. A sanitary sewer system is a wastewater collection system designed to convey domestic, commercial, and industrial wastewater to the treatment facility. This system can include limited amounts of inflow and infiltration from groundwater and stormwater, but it is not designed to collect large amounts of runoff from precipitation events. Untreated or partially treated discharge from a sanitary sewer system is referred to as a sanitary sewer overflow. Sanitary sewer overflows can be caused by a variety of factors including blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur during either dry or wet weather and at any point in the collection system including overflows from manholes or backups into private residences. These types of discharges are not authorized by the federal Clean Water Act and should be rare and eliminated to the maximum extent possible. A review of sanitary sewer overflows during the past five years that may have contributed pollutant loading to Bear Creek shows the occurrence of 11 overflows reported by the Kirksville Wastewater Treatment Facility since 2014. The last reported sanitary sewer overflow occurred on May 2, 2017.

6.1.2 Site-Specific Industrial and Non-Domestic Wastewater Permits

Industrial and non-domestic facilities discharge wastewater resulting from non-sewage generating activities. At the time of this report, there are no site-specific industrial or non-domestic wastewater permitted facilities in the subject watershed.

6.1.3 CAFO Permits

Concentrated animal feeding operations (CAFOs) are animal feeding operations that confine, feed, and maintain more than 1,000 animal units for 45 days or more during any 12-month period. Facilities with fewer animal units may be permitted as CAFOs if discharges occur or other water quality issues are discovered per 10 CSR 20-6.300. In Missouri, these types of facilities are permitted with either a site-specific permit or one of two available CAFO general permits. At the time of this report, there are no permitted facilities of this type in the subject watershed.

6.1.4 Municipal Separate Storm Sewer System Permits

An MS4 is a stormwater conveyance system owned by a public entity that is not a combined sewer or part of a sewage treatment plant. Federal regulations issued in 1990 require discharges from such systems to be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more. In 1999, new federal regulations required permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area, or have otherwise been designated as needing a permit by the permitting authority. Pollutant loading from these areas would be similar to nonpoint sources occurring through stormwater runoff (e.g., fertilizers from lawns, erosion, and yard debris), and potentially from sanitary sewer overflows entering the system. Although stormwater discharges are often untreated, MS4 permit holders must develop, implement, and enforce stormwater management plans to reduce the contamination of stormwater runoff and prohibit illicit discharges. These plans must include measurable goals, be reported on annually, and meet six minimum control measures. These six minimum control measures are public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention. There are two applicable MS4 permits in the Bear Creek watershed (Table 8). Stormwater discharges from the City of Kirksville are regulated through a general stormwater permit and stormwater discharges from highways and rights-of-ways managed by MoDOT in Kirksville are regulated through a site-specific permit. The site-specific permit is applicable to all MoDOT maintained highways and rights-of-way in MS4 urban areas statewide and is commonly referred to as a transportation separate storm sewer system (TS4).

Table 8. Permitted MS4s in Subject Watershed of Bear Creek

Facility	Permit No.	Expires
Kirksville Small MS4	MO-R040078	9/30/2021
MoDOT TS4	MO-0137910	10/31/2021

Urban stormwater runoff can contain high levels of nitrogen and phosphorus that may result in nutrient loading to streams, which can contribute to excess algae growth resulting in low dissolved oxygen conditions. During low precipitation and critical low flows, nutrients originating from fertilizer placed on residential lawns, cemeteries, parks, and other vegetated areas are transported into storm sewers via runoff from sprinkler irrigation. Hobbie et al. (2017) found that pet (dog) waste may contribute 76 percent of total phosphorus inputs and 28 percent of total nitrogen inputs

in urban areas. Hobbie et al. (2017) also found that export of phosphorus contributes 32 to 68 percent of storm drain nutrient outputs. Phosphorus transport is especially high in urban areas due to impervious surfaces which inhibit infiltration of soluble phosphorus and the phosphorus-laden runoff is carried to storm drains. In contrast, nitrogen transport is inhibited by up to 83 percent retention in unfertilized parks and storm drain catch basins and pipes.

The Kirksville municipal area accounts for 23 percent of the total subject watershed area. Urban (developed) areas of the city account for 16 percent of the subject watershed and include areas that are 20 to 80 percent impervious. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Water quality data for Bear Creek in July 2009 show low dissolved oxygen concentrations in the City of Kirksville upstream of the Kirksville Wastewater Treatment Facility. This indicates that urban areas contribute nutrient loading to the impaired segment of Bear Creek during the critical low-flow condition, likely due to transport by sprinkler irrigation.

The area potentially contributing runoff to the MoDOT TS4 in Kirksville is 0.26 square miles and is comprised primarily of highways. This accounts for only 1 percent of the total area of the subject watershed. Due to the small amount of area draining to the TS4, and the lack of sources likely to contribute significant amounts of sediment or nutrients, the MoDOT TS4 does not cause or contribute to the impairment of Bear Creek.

6.1.5 General Wastewater and Non-MS4 Stormwater Permits

General and stormwater permits are issued based on the type of activity occurring and are intended to be flexible enough to allow for ease and speed of issuance, while providing the required protection of water quality. General and stormwater permits are issued for activities similar enough to be covered by a single set of requirements and are designated with permit numbers beginning with “MO-G” or “MO-R,” respectively.

In June 2019, there was one active general permit in the subject watershed. The Truman State University Swimming Pool has an active general permit for swimming pool discharges (MO-G76) (Table 9). This permit allows the discharge of filter backwash and pool drainage from chlorinated swimming pools. Discharge from this facility does not cause or contribute to the impairment in Bear Creek.

Table 9. Point Sources in the Subject Watershed of Bear Creek

Facility	Permit No.	Design Flow	Actual Flow	Expires
Truman State University Swimming Pool	MO-G760136	N/A	N/A	7/31/2019

Table 10 presents a list of the non-MS4 stormwater permits in the subject watershed, as of June 28, 2019. Permits associated with construction or land disturbance activities (MO-RA) are temporary. The number of effective permits of this type may vary widely in any given year. Despite this variability, final TMDL targets and allocations do not vary as a result of any changes in the numbers of these types of permits. For this TMDL, the Department assumes the temporary land disturbance activities described in Table 10, as well as any future general or stormwater permitted activities, will be conducted in compliance with all permit conditions, including monitoring and

discharge limitations. It is expected that compliance with these permits will be protective of the applicable designated uses within the watershed. For these reasons, general wastewater and stormwater permits are not expected to cause or contribute to the aquatic life impairment of Bear Creek. At any time, if the Department determines that the water quality of streams in the watershed is not being adequately protected, the Department may require the owner or operator of the permitted site to obtain a site-specific operating permit per 10 CSR 20-6.010(13)(C).

Table 10. Stormwater (MO-R) Permitted Facilities

Permit No.	Facility Name	Permit Type	Expires
MO-RA09540	Twin Pines Adult Care Center	Construction or land disturbance	2/7/2022
MO-RA09832	Truman State University	Construction or land disturbance	2/7/2022
MO-RA09983	Ameren Adair Substation	Construction or land disturbance	2/7/2022
MO-RA10330	Holiday Inn Kirksville	Construction or land disturbance	2/7/2022
MO-RA12109	Ameren Zachary Substation	Construction or land disturbance	2/7/2022
MO-RA12115	Mark Twain Transmission Line	Construction or land disturbance	2/7/2022

6.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential point sources of nutrients and oxygen consuming substances. These types of sewage discharges bypass treatment systems, such as a septic tank or a sanitary sewer, and instead discharge directly to a stream or an adjacent land area (Brown et al. 2004). Illicit straight pipe discharges are illegal and not authorized under the federal Clean Water Act. At present, there are no data about the presence or number of illicit straight pipe discharges in the subject watershed. For this reason, it is unknown to what significance straight pipe discharges contribute pollutant loads to Bear Creek. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated. Illicit discharge detection and elimination is one of the six minimum control measures required by an MS4 permit. Therefore, such sources in areas serviced by MS4s are expected to be detected and eliminated in accordance with existing permitted conditions.

6.2 Nonpoint Sources

Nonpoint source pollution refers to pollution coming from diffuse, non-permitted sources that typically cannot be identified as entering a water body at a single location and include all other categories of pollution not classified as being from a point source. Nonpoint sources are exempt from Department permit regulations per state rules at 10 CSR 20-6.010(1)(B)1. These sources involve stormwater runoff over land and are typically minor or negligible under low-flow conditions. However, sediment and organic material carried into streams during high precipitation events can accumulate in the receiving streambed. Decomposition of these accumulations can contribute to increased oxygen demand during low-flow conditions when water temperatures are warmer and flowing too slowly for adequate reaeration. Runoff from agricultural areas and non-MS4 permitted urban areas, onsite wastewater treatment systems, and areas with poor riparian corridor conditions are typical sources of nonpoint pollutants that contribute to water quality impairments.

6.2.1 Agricultural Runoff

Stormwater runoff and soil erosion from lands used for agricultural purposes (hay and pasture, and cropland) are a source of sediment and nutrient loading. Fertilizer is applied to agricultural lands as

chemical forms of nitrogen and phosphorus and as animal manure. Application rates and timing vary by site depending upon a number of factors, including manure quality and soil fertility. Livestock that are not excluded from streams may deposit manure directly into waterways. Operations using nutrient management plans to guide fertilizer applications and employ best management practices to reduce soil erosion and exclude animals from streams will contribute smaller nutrient and sediment loads than those that do not.

As noted in Sections 3.1 and 3.4 of this document, 100 percent of soils in the subject watershed have moderate to high runoff potential at some time of the year and agricultural areas (cropland and pastureland) account for 66.9 percent of the watershed. Activities associated with agricultural land use such as fertilization and tilling increase the quantity of nutrients and erosion potential on agricultural lands, and facilitate loading into streams. Nonpoint source runoff from agricultural activities contribute substantial nitrogen and sediment loading to Bear Creek during high flows due to complete coverage in the watershed by silt and loam soils. These soils have high erodibility and runoff potential to tributaries of, as well as directly to, Bear Creek. This loading as well as other organic materials transported from agricultural areas during high flows accumulates in the streambed of Bear Creek, which then contributes to high oxygen demand during low flows when Bear Creek is flowing too slowly for turbulence to reaerate the water column. Available water quality data, and the QUAL2K model inputs and assumptions presented in Appendix A, support this conclusion.

6.2.2 Unregulated Urban Runoff

The primary source of urban runoff in the watershed is from the City of Kirksville. As mentioned previously, stormwater discharges from Kirksville are regulated by a MS4 permit. For this reason, there are minimal unregulated urban runoff contributions to the impaired segment of Bear Creek. Unregulated urban runoff sources do not likely cause or contribute to the impairment of Bear Creek.

6.2.3 Onsite Wastewater Treatment Systems

Approximately 25 percent of homes in Missouri utilize onsite wastewater treatment systems, particularly in rural areas where public sewer systems may not be available (DHSS 2018). Onsite wastewater treatment systems treat domestic wastewater and disperse it on the property from where it is generated (i.e., a home septic system). When properly designed and maintained, such systems perform well and should not serve as a source of contamination to surface waters. However, onsite wastewater treatment systems can fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley and Witten 1996). Failing onsite wastewater treatment systems can contribute nutrient loads and oxygen consuming substances to nearby streams under wet or dry weather conditions through surface runoff and groundwater flows. Onsite wastewater treatment systems may contribute pollutants to waterbodies directly or as component of stormwater runoff.

The exact number of onsite wastewater treatment (septic) systems in the subject watershed is unknown. EPA’s online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers and population per system by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA

2014b).[12] Estimates of septic system numbers are provided in Table 11 and are based on the 2010 rural population estimate in Table 4 and the population per system provided by the STEPL input data server. Due to the relatively stable rural population since the 1990 census, this data is assumed to provide a reasonable estimate of septic system numbers. Table 11 also provides statewide estimated failure rates from a study by the Electric Power Research Institute (EPRI 2000). The study suggests that in some areas in Missouri, up to 50 percent of onsite wastewater treatment systems may be failing. Although failing onsite wastewater treatment systems are potential sources of nutrient loading and organic sediment through overland flow, the significance of such contributions to the impaired segment of Bear Creek is likely minimal. Due to the availability of wastewater treatment in the City of Kirksville where the majority of the subject watershed population resides, onsite wastewater treatment systems are not expected to be a major contributor to the impairment in Bear Creek.

Table 11. Estimates of Septic System Number in the Subject Watershed

2010 Rural Population	Population per System	Number of Systems	Potential Failure Rates
632	3	211	30 – 50%

6.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on in-stream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal, and assimilation of pollutants in runoff. Therefore, a stream with good riparian cover is often better able to mitigate the impacts of high pollutant loads than a stream with poor or no riparian cover. Shade provided by riparian corridors is also important because it helps to keep water cooler and reduce temperature variation, especially during the critical low flows of July and August.

As noted in Section 3.1, soils in the Bear Creek watershed consist of silt loam and clay loam which are fine-grained soils. Due to the presence of these soils in and adjacent to Bear Creek, and the absence of coarser-grained sand and gravel, the natural condition of Bear Creek would not provide high quality habitat for macroinvertebrates and may inhibit the reproductive habits of fish. The fine-grained soils also contribute to high turbidity due to the presence of suspended solids in the stream when precipitation is high. This natural condition likely contributes to low fish and macroinvertebrate diversity due to poor quality substrate, as well as light and oxygen limitations.

Table 12 presents land cover calculations for the area within 100 feet (30 meters) of the impaired segment of Bear Creek and all tributaries in the upper part of the watershed where the impaired segment is located. Note that nine percent of the riparian corridor is located in developed areas and 50.7 percent is located in hay and pasture lands. Both land uses contribute sediment and nutrient loading during precipitation events due to erosion and stormwater runoff into Bear Creek.

Table 12. Land Cover within 100 feet (30 meters) of the Impaired Segment and Tributaries

Land Cover	Area (mi^2)	Percent
Barren Land	0.003	0.1%
Developed	0.208	9.0%
Cultivated Crops	0.043	1.9%
Hay and Pasture	1.170	50.7%

[12] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

Forest	0.717	31.1%
Shrub and Herbaceous	0.064	2.8%
Wetlands	0.057	2.5%
Open Water	0.044	1.9%
Total	2.306	100.0%

7. Numeric TMDL Targets and Modeling Approach

The pollutant targets in this revised TMDL have been established such that dissolved oxygen concentrations in Bear Creek will meet the minimum criterion of 5.0 mg/L and the warm water habitat (aquatic life) designated use will be restored. Since dissolved oxygen is not a pollutant and cannot be allocated in a TMDL, other numeric targets that will result in attainment of the water quality standards identified in Section 4 of this document have been selected to address the unknown impairment identified on the 2008 303(d) List. These targets include total nitrogen, total phosphorus, biochemical oxygen demand, and ammonia nitrogen. Applicability and support for the selected targets are provided using a QUAL2K model. To address potential violations of the general criteria associated with excess sedimentation, an additional total suspended solids target is also included in this TMDL. The load duration curve approach was used to calculate acceptable loading and allocations of total suspended solids. The inclusion of a total suspended solids target also addresses additional organic loading that may occur from point source discharges, as well as additional nutrient loading from nonpoint sources.

7.1 Sediment and Nutrients

Sediment transported into streams from point and nonpoint sources contains nitrogen and phosphorus (nutrients) and can result in the depletion of dissolved oxygen concentrations as oxygen is used to facilitate the biochemical processes of decomposition. In the presence of organic sediment and nutrients, dissolved oxygen in the stream is consumed faster than it can be replenished through atmospheric oxygen exchange and aquatic organism photosynthesis. This results in low dissolved oxygen until the organic matter has been decomposed enough that dissolved oxygen replenishment exceeds dissolved oxygen consumption. Inorganic sediment has less of an effect on in-stream dissolved oxygen concentrations than organic sediment. However, inorganic sediment deposition can alter stream geomorphology, reduce available habitat, and can smother macroinvertebrate larvae and fish eggs. Excessive sedimentation of interstitial spaces also reduces available habitat for fish and macroinvertebrates, while lowering reaeration potential in these habitats through decreased turbulence and reaeration.

7.2 Total Suspended Solids

Total suspended solids are solids suspended (i.e., floating) in stream water or wastewater effluent and include both inorganic and organic sediments. Total suspended solids are comprised of both inorganic solids such as gravel and sand, as well as decomposable organic solids such as sewage particulates. Point sources reduce or remove total suspended solids through filtration of effluent, while nonpoint sources reduce total suspended solids through control of sediment erosion using best management practices. Because phosphorus can adhere to soil carried in runoff and organic sediment is a component of total suspended solids, reductions in total suspended solids are expected to result in additional nutrient and organic loading reductions that impact overall instream dissolved oxygen concentrations.

7.3 Biochemical Oxygen Demand

Biochemical oxygen demand is representative of both the quantity of organic materials in effluent and the concentration of dissolved oxygen in the receiving stream. Biochemical oxygen demand is composed of carbonaceous biochemical oxygen demand (CBOD) (i.e., the amount of oxygen needed for the microbial utilization of carbon compounds) and nitrogenous biochemical oxygen demand (NBOD) (i.e., the amount of oxygen needed for the microbial oxidation of certain nitrogen compounds). NBOD is estimated directly from Total Kjeldahl Nitrogen (TKN), which is ammonia nitrogen (NH_4-N) plus organic nitrogen.

7.4 Ammonia as Nitrogen (NH_4-N)

Ammonia as nitrogen can influence water quality in natural systems in two ways. The nitrification process in which ammonia nitrogen (NH_4-N) is reduced to nitrate (NO_3) consumes an estimated 4.2-4.6 grams of oxygen as O_2 per gram of ammonia as NH_4 (Cox 2003). As NBOD, high NH_4-N concentrations in wastewater effluent exert a high oxygen demand that can contribute to low dissolved oxygen in receiving streams. In addition to depleting oxygen, ammonia can be toxic to aquatic life and must not exceed the concentrations found in Tables B1 and B2 of Missouri's Water Quality Standards. Water quality targets for ammonia as nitrogen must be protective of both possible pathways.

7.5 QUAL2K Modeling

QUAL2K is a steady state model based on the Streeter-Phelps equation that estimates the effects of point source biochemical oxygen demand from sewage effluent on receiving stream dissolved oxygen concentrations. QUAL2K simulates the link between dissolved oxygen and biochemical oxygen demand. The QUAL2K model calculates biochemical oxygen demand by using $CBOD_5$, organic nitrogen, and ammonia as nitrogen data from the wastewater treatment facility's discharge monitoring report and produces estimates of in-stream dissolved oxygen concentrations.

Two QUAL2K models, a calibration model and a critical condition model, were developed to determine allowable pollutant loading in Bear Creek. For the calibration model, observed data were used to adjust the model to simulate stream characteristics. Nine tributaries were used in the calibration model to represent nonpoint source loading, which is a substantial contributing source of pollutants to Bear Creek. The calibration model inputs were based on data recorded at seven sample points along Bear Creek on July 15, 2009, and documented in the discharge monitoring report for the Kirksville Wastewater Treatment Facility on July 30, 2009. Use of the observed data, especially for stream hydrology and from facility records, did not always contribute to a well-calibrated QUAL2K model. Support for adjustments to input data and assumptions used to calibrate the model are presented in Appendix A. The critical condition model uses the calibrated stream characteristics to simulate a low-flow critical condition when the Kirksville Wastewater Treatment Facility is expected to be the predominant source of flow in Bear Creek, and in-stream conditions are most likely to result in low dissolved oxygen impairment. The 2019 QUAL2K critical condition model demonstrates that Missouri Water Quality Standards are attained when wasteload allocations are applied to the Kirksville Wastewater Treatment Facility. The critical condition model demonstrates that wasteload allocations result in attainment of the minimum dissolved oxygen criterion under low-flow critical conditions. The wasteload allocations are expected to result in attainment of the minimum dissolved oxygen criterion under other flow conditions when additional reaeration

through turbulence and increased pollutant dilution are more likely. Model assumptions, tables of model inputs, and graphical model outputs are provided in Appendix A.

7.6 Total Suspended Solids Load Duration Curve

The load duration curve approach was used to calculate the allowable loading of total suspended solids into Bear Creek. The load duration approach provides a visual representation of stream flow conditions and the pollutant loading that will attain surface water quality targets during those flow conditions. When observed data from the impaired water body is available, the load duration curve approach is also useful in identifying and differentiating between storm-driven and steady-input sources, which can then inform appropriate restoration actions. To develop the total suspended solids load duration curve for Bear Creek, a flow duration curve was developed using a synthetic flow derived from the average daily flow data collected from multiple USGS stream gages in the ecological drainage unit (EDU) where Bear Creek is located. For this TMDL, the targeted pollutant loading for total suspended solids is based on the 25^{th} percentile concentration of all USGS total suspended solids data available from Missouri in the EDU for which Bear Creek is located. The concentration target calculated using this approach is 15 mg/L. Additional discussion about the methods used in the modeling and development of the total suspended solids load duration curve for Bear Creek is presented in Appendix B.

8. Calculating Loading Capacity

A TMDL calculates the loading capacity of a water body and allocates that load among the various pollutant sources in the watershed. The loading capacity is the maximum pollutant load that a water body can assimilate and still meet water quality standards. The TMDL is equal to the sum of the wasteload allocations, load allocations, and the margin of safety:

$$\text{TMDL} = \text{LC} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$$

where LC is the loading capacity, ΣWLA is the sum of the wasteload allocations, ΣLA is the sum of the load allocations, and MOS is the margin of safety.

The following formula is used to convert pollutant concentrations to pounds/day:

(flow in ft^3/sec)(maximum allowable pollutant concentration in mg/L)(5.395*)= pounds/day
*5.395 is the conversion factor used to obtain units of pounds/day.

For this TMDL, the pollutant loading capacity for biochemical oxygen demand, nutrients, and ammonia as nitrogen are calculated at critical low-flow conditions when in-stream conditions are most likely to result in violations of Missouri's dissolved oxygen criterion due to increased temperature, and limited dilution and flow. For total suspended solids, the loading capacity is calculated for all flows using a load duration curve (Figure 10). For all pollutants, the loading capacity is equal to the sum of the nonpoint source load allocation and the sum of wasteload allocations to the Kirksville MS4 and the Kirksville Wastewater Treatment Facility. An implicit margin of safety was used for all TMDL calculations. The pollutant loading capacity and allocations for the impaired segment of Bear Creek during critical low-flow conditions is presented in Table 13. For total suspended solids, loading capacity and allocations at various flows are presented in Table 14. Additional discussion regarding specific allocations of the loading capacity and margin of safety is provided in the following sections.

Table 13. Low Flow TMDL for Bear Creek

Pollutant	Loading Capacity (lbs/day)	∑Wasteload Allocation (lbs/day)	∑Load Allocation (lbs/day)
BOD_5	240.7	217.08	23.627
TP	17.18	16.7	0.484
NH_3-N	33.4	33.4	0
TN	481.39	467.54	13.85

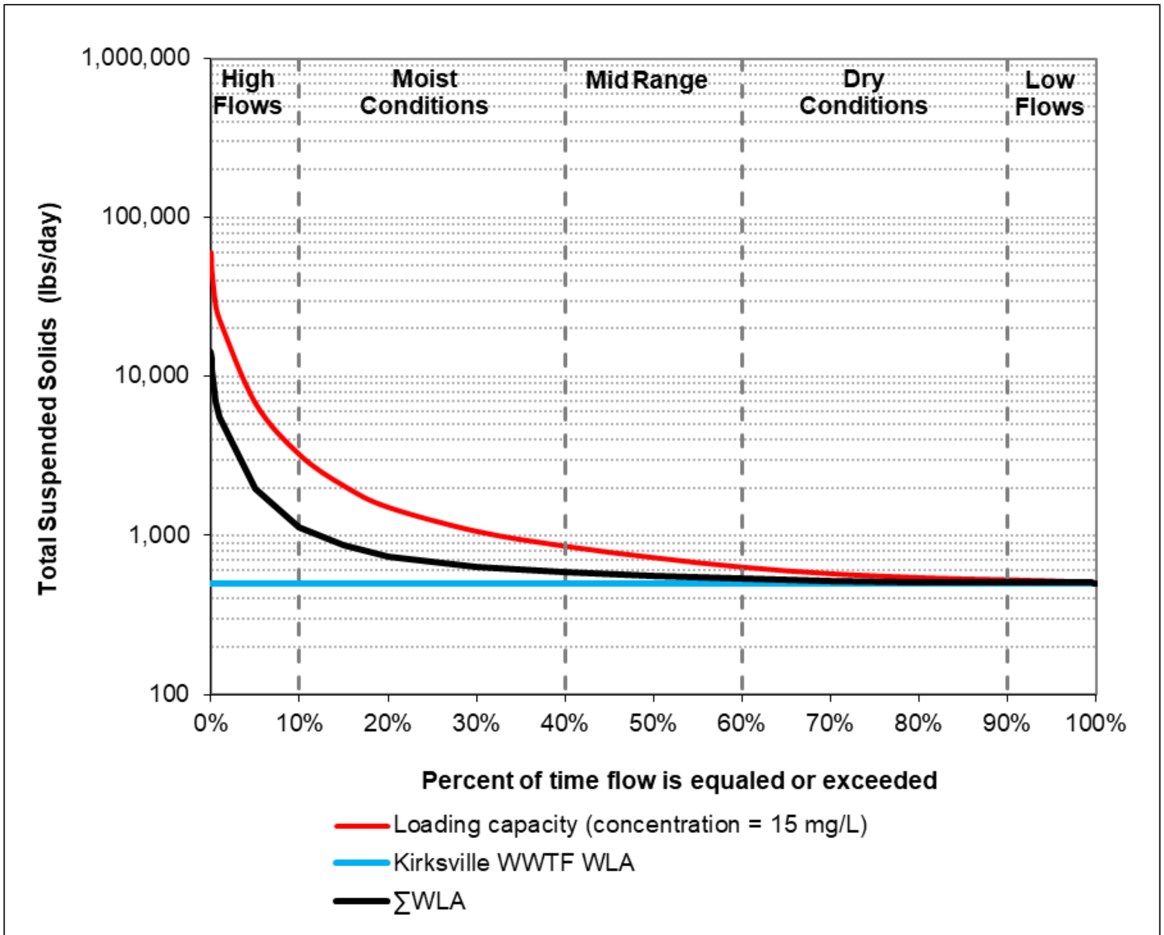

Figure 10. Total Suspended Solids Load Duration Curve

Table 14. Total Suspended Solids TMDL and Allocations at Various Flows

Percent of time flow equaled or exceeded	Flow (cfs)	Loading Capacity (lbs/day)	∑Wasteload Allocation (lbs/day)	∑Load Allocation (lbs/day)
95	6.4	520	506	14
75	6.9	560	515	45
50	9.0	730	555	175
25	15.3	1,238	672	566
5	84.5	6,834	1,965	4,869

9. Wasteload Allocation (Allowable Point Source Load)

The wasteload allocation is the allowable amount of the loading capacity assigned to existing or future point sources. This section discusses the rationale and approach for assigning wasteload allocations to point sources in the subject watershed as well as considerations given for future sources. Typically, point sources permit limits for a given pollutant are the most stringent of either technology-based effluent limits or water quality-based effluent limits. Technology-based effluent limits are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. Water quality-based effluent limits represent the most stringent concentration of a pollutant that a receiving stream can assimilate without violating applicable water quality standards at a specific location. Final effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations per 40 CFR 122.44(d)(1)(vii)(B). Mixing zones and zones of initial dilution are not allowed in regulation for streams with 7Q10 low flows of less than 0.1 cubic feet per second [10 CSR 20-7.031(5)(A)4.B.(I)]. The Bear Creek 7Q10 low flow, estimated just upstream of the Kirksville Wastewater Treatment Facility,[13] is 0.00128 cubic feet per second. Therefore, in order to ensure attainment of applicable water quality standards in Bear Creek, all water quality targets must be met at end of pipe. The wasteload allocations in this TMDL report do not authorize any facility to discharge pollutants at concentrations that exceed water quality standards.

9.1 Municipal and Domestic Wastewater Discharges

As noted in Table 6 there are two domestic wastewater treatment facilities in the subject watershed. Wasteload allocations for the Kirksville Wastewater Treatment Facility were established using steady state QUAL2K models and are presented in Table 15. QUAL2K modeling also demonstrated that the Burk Subdivision Wastewater Treatment Facility does not cause or contribute to the impairment in Bear Creek due to its small design flow and distance from the impaired water body. The Burk Subdivision model demonstrated that existing loading from the facility does not result in loading that exceeds the sum of the wasteload allocations. For this reason, wasteload allocations to the Burk Subdivision Wastewater Treatment Facility are set at existing permit limits and conditions. The wasteload allocations for the Kirksville Wastewater Treatment Facility are based on the facility’s design flow and appropriate pollutant concentration targets shown by QUAL2K to attain the minimum dissolved oxygen water quality criterion of 5.0 mg/L for the protection of warm water habitat. Wasteload allocations designated to the Kirksville Wastewater Treatment Facility are applicable at all flows. In addition to authorized discharges from municipal wastewater treatment facilities, areas serviced by sanitary sewer systems risk nutrient contributions from accidental overflows. As mentioned in Section 6.1.1 of this document, sanitary sewer overflows are unpermitted discharges and not authorized under the federal Clean Water Act. For this reason, sanitary sewer overflows are assigned a wasteload allocation of zero.

[13] Per StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications https://streamstats.usgs.gov/ss/

Table 15. Wasteload Allocations for Domestic Wastewater Dischargers in the Subject Watershed

Effluent Parameter	Design Flow (MGD)	Existing Permit Limit		WLA at Design Flow		Percent Reduction
		Concentration (mg/L)	Load (lbs/day)	Concentration (mg/L)	Load (lbs/day)	
Kirksville WWTF (MO-0049506)						
BOD_5	4	Monthly Average = 30	1,003	6.5	217.08	78%
TP	4	No Existing Limit	N/A	0.5	16.70	N/A
NH_3-N	4	Monthly Average = 7.8	260	1.0	33.40	87%
TN	4	No Existing Limit	N/A	14.0	467.54	N/A
TSS	4	Monthly Average = 30	1,003	15.0	502	50%
DO*	4	N/A	N/A	6.0	N/A	N/A
Burk Subdivision WWTF (MO-0107557)						
Same as above	0.011100	N/A	N/A	Existing permit limits and conditions		N/A
Sanitary Sewer Overflows						
Illegal discharge				0		N/A

* Water quality standards will be attained with the wasteload allocations described in this table when the dissolved oxygen concentration in the discharged effluent is at a minimum of 6.0 mg/L

For point source reductions to achieve the specified loading targets, additional upgrades to the Kirksville Wastewater Treatment Facility, such as biological or enhanced nutrient removal, may be necessary.

9.2 Site-Specific Permitted Industrial and Non-Domestic Wastewater Facilities

There are no site-specific permitted industrial and non-domestic wastewater facilities in the subject watershed of Bear Creek. Therefore, such sources are not assigned a portion of the calculated loading capacity.

9.3 CAFOs

There are no CAFOs in the subject watershed of Bear Creek, thus CAFOs are not assigned a portion of the calculated loading capacity.

9.4 MS4 Permits

As mentioned in Section 6.1.4, urban runoff is a potential contributor of sediment and nutrient loading to streams. During periods of low precipitation and critical low flows, pollutants transported through storm sewers typically result from lawn irrigation and car washing on residential properties.[14] The Kirksville MS4 has been assigned wasteload allocations during low-flow conditions as presented in Table 16 because water quality data for Bear Creek showed low dissolved oxygen concentrations upstream of the Kirksville Wastewater Treatment Facility in July 2009. These wasteload allocations represent the average concentrations of biochemical oxygen

[14] Missouri's general MS4 permit allows various non-stormwater discharges including, but not limited to, irrigation, street wash water, residential car washing, residential swimming pool discharges, and air conditioning condensate.

demand, total phosphorus, total nitrogen, and ammonia nitrogen recorded on August 25 and 26, 2009 when dissolved oxygen concentrations at Sample Point 1 were greater than the minimum criterion of 5.0 mg/L. Kirksville MS4 wasteload allocations for total suspended solids were derived for various flows using the load duration curve approach, and are presented in Table 17. Total suspended solids wasteload allocations are based on the proportion of municipal area and available loading after allocations to the Kirksville Wastewater Treatment Facility. Upon approval of this TMDL, the City of Kirksville will be required by their permit to develop an Assumptions and Requirements Attainment Plan for the MS4 to incorporate best management practices consistent with the goals of this TMDL.

The MoDOT TS4 receives runoff primarily from highways, accounts for less than 1 percent of the total watershed area, and is not expected to contribute significant loads of sediment, nutrients, or oxygen consuming substances to Bear Creek (Section 6.1.4). For this reason, no specific portion of the loading capacity is allocated to the MoDOT TS4. Existing permit conditions and continued implementation of required stormwater management programs are expected to result in *de minimis* pollutant loading that will not exceed the total wasteload allocation.

Table 16. Low Flow MS4 Wasteload Allocations

Effluent Parameter	**WLA**	
	Concentration (mg/L)	**Load (lbs/day)**
Kirksville Small MS4 (MO-R040078)		
BOD_5	1.6	0.0091
TP	0.075	0.0004
TN	0.900	0.0051
NH_3-N	0.630	0.0036
MoDOT TS4 (MO-0137910)		
Same as above	*de minimis* / BMPs	

Table 17. Total Suspended Solids Wasteload Allocations for the Kirksville MS4

Percent of time flow equaled or exceeded	**Flow (cfs)**	**Loading Capacity (lbs/day)**	**MS4 Wasteload Allocation (lbs/day)**
95	6.4	520	4
75	6.9	560	13
50	9.0	730	53
25	15.3	1,238	170
5	84.5	6,834	1,463

9.5 General Wastewater and Non-MS4 Stormwater Permits

Activities permitted through general or stormwater permits are not expected to contribute significant pollutant loads to surface waters. It is expected that compliance with these types of permits will be protective of the warm water habitat use designated to Bear Creek. For this reason, these types of facilities are not assigned a specified portion of the calculated loading capacity and wasteload allocations are set at existing permit limits and conditions, which are assumed to result in pollutant loading at *de minimis* concentrations that will not exceed the total wasteload allocation.

9.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are assigned a wasteload allocation of zero. Any existing sources of this type must be eliminated.

9.7 Considerations for Future Point Sources

For this TMDL, no specific portion of the loading capacity is allocated to a reserve capacity. However, the wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources in the watershed. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional loading will affect, and any additional requirements associated with antidegradation. Per federal regulations at 40 CFR 122.4(a), no permit may be issued when the conditions of the permit do not provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. Facility types not currently existing in the watershed and not allocated a portion of the loading capacity may be permitted as no discharge facilities as long as permit conditions for land application or other controls maintain potential loading at *de minimis* concentrations. Future general (MO-G) and stormwater (MO-R) permitted activities that operate in full compliance with permit conditions are not expected to contribute pollutant loads above *de minimis* levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations. Decommissioning of onsite wastewater treatment systems and home connection to a sewerage system for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL. Wasteload allocations calculated for the Kirksville Wastewater Treatment Facility are based on design flow instead of actual flow and will account for future discharge increases. Wasteload allocations between point sources may also be appropriately shifted between individual point sources where pollutant loading has shifted as long as the sum of the wasteload allocations is unchanged. In some instances a potential source may be re-categorized from a nonpoint source to a point source (e.g., newly designated MS4s or other permitted stormwater). If such a source's magnitude, character, and location remain unchanged, then the appropriate portion of the load allocation may be assigned as a wasteload allocation.

10. Load Allocation (Nonpoint Source Load)

The load allocation is the amount of the pollutant load that is assigned to existing and future nonpoint sources, as well as natural background contributions (40 CFR § 130.2(g)). Nine tributaries were used in the calibrated QUAL2K model to account for nonpoint source contributions to organic nitrogen, organic phosphorus, and low dissolved oxygen that were recorded in water quality data, but were not representative of existing point source inputs alone. The specific values assigned to each tributary are not necessarily representative of the specific contributions of each sub-basin, rather the values were used to calibrate the QUAL2K model to observed data in Bear Creek (Appendix A). The load allocation at low flow conditions was calculated as the sum of the pollutant loading represented by the nine tributaries after a 30 percent reduction in pollutant concentrations was applied. This reduction is necessary to raise the dissolved oxygen concentration in Bear Creek above the minimum 5.0 mg/L. The resulting sum of the nonpoint source load contributions from the nine tributaries represents the load allocation for the entire watershed. Load allocations during critical low-flow conditions are presented in Table 18. For total suspended solids, the load duration

curve approach was used and load allocations were calculated as the remainder of the loading capacity after allocations to the wasteload allocation. Load allocations for total suspended solids at varying flows are presented in Table 19.

Table 18. Low Flow Nonpoint Source Load Allocations

BOD_5 (lbs/day)	TN (lbs/day)	TP (lbs/day)
23.627	13.85	0.484

Table 19. Low Flow Total Suspended Solids Nonpoint Source Load Allocations

Percent of time flow equaled or exceeded	Flow (cfs)	Loading Capacity (lbs/day)	Load Allocation (lbs/day)
95	6.4	520	14
75	6.9	560	45
50	9.0	730	175
25	15.3	1,238	566
5	84.5	6,834	4,869

11. Margin of Safety

A margin of safety is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA 303(d)(l)(C) and 40 CFR 130.7(c)(l)). The margin of safety is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety as part of the critical conditions for the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

For this TMDL an implicit margin of safety was used. The margin of safety was incorporated into the development of this TMDL by making conservative assumptions in the analysis as follows:

- The 7Q10 low flow value was used for the headwater flow rates.
- QUAL2K estimates the oxygen demand for the nitrification of ammonia nitrogen (NH_4) to nitrate (NBOD) twice because where the model asks for carbonaceous oxygen demand ($CBOD_5$), total biochemical oxygen demand (CBOD + NBOD) from the facility's discharge monitoring report was entered in addition to ammonia nitrogen.
- Total suspended solids targets are based on the 25th percentile concentration of all USGS total suspended solids data available from Missouri in the EDU in which Bear Creek is located. Additionally, because phosphorus can adhere to soil carried in runoff and organic sediment is a component of total suspended solids, reductions in total suspended solids are expected to result in additional nutrient and organic loading reductions that impact overall instream dissolved oxygen concentrations.

12. Seasonal Variation

Federal regulations at 40 CFR §130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable standards. This TMDL considered seasonal variation by assuming that the

Kirksville Wastewater Treatment Facility accounts for the majority of the flow in Bear Creek during critical low-flow conditions. Critical low-flow conditions represent the highest stream temperatures and lowest flows, when assimilation of pollutants and reaeration of dissolved oxygen are the most difficult. This likely results in an over-estimate in the winter season when flows from stormwater and snow melt contribute to stream flow volume and dilution at lower temperatures. Reductions in nonpoint source loading would occur during wetter months when stream flows are higher, but will result in attainment of water quality standards during summer low-flow conditions by reducing accumulations of organic material that require oxygen for decomposition. The Missouri Water Quality Standards account for seasonal variation by establishing ammonia as nitrogen criteria based on pH and temperature such that the criteria are more stringent when water temperatures are higher. In addition, colder water (winter) holds more oxygen, but calculations of loading capacity are based on achieving the dissolved oxygen criterion of 5.0 mg/L during summer low-flow conditions and during the warmest temperatures, which offers the maximum protection for the stream. For total suspended solids, the load duration curve developed for this TMDL represent streamflow under all conditions as it was developed using numerous years of flow data collected during all seasons. For this reason, the total suspended solids targets and allocations found in this TMDL report will be protective of applicable general criteria during all seasons and under all flow conditions.

13. Monitoring Plans

The Department often schedules and carries out post-TMDL monitoring within a reasonable timeframe following completion of permit compliance schedules, facility upgrades, or the implementation of watershed best management practices. Due to the 2017 upgrade of the Kirksville Wastewater Treatment Facility, constituent monitoring of Bear Creek is currently scheduled for July and August 2020, and biological monitoring is scheduled for Spring 2021. Data collected during such monitoring will be used for determining attainment or continued impairment of water quality standards as part of the Department's biennial water quality assessments required for federal Clean Water Act 305(b) and 303(d) reporting. The data derived from this monitoring may also be used for adjusting pollutant reduction goals and informing implementation activities. Furthermore, the Department will also routinely examine any available quality-assured water quality data collected from Bear Creek by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may potentially be considered for monitoring water quality following TMDL implementation.

14. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the National Pollutant Discharge Elimination System (NPDES) permitting program. State operating permits requiring effluent and in-stream monitoring be reported to the Department should provide reasonable assurance that in-stream water quality standards will be met. The Department regulates point source discharges from the Kirksville Wastewater Treatment Facility through Missouri State Operating Permit MO-0049506 and from the Kirksville MS4 through Missouri State Operating Permit MO-R040078.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or best management practices within the watershed. If best management practices or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or best management practices are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur. This TMDL assumes discharge from the Kirksville Wastewater Treatment Facility is the primary source of flow in Bear Creek during critical low-flow conditions. Therefore, this TMDL does not include wasteload allocations that are less stringent than the water quality targets determined to attain water quality standards.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Additionally, cost-share opportunities for implementation of agricultural best management practices are also available. Examples of nonpoint source reduction practices implemented in the Upper Bear Creek subwatershed between 2014 and 2019 are presented in Table 20. These practices reduce both sediment and nutrient transport into streams by reducing overland runoff and erosion.

Additional information regarding potential funding sources, cost-share opportunities, and implementation actions addressing pollutant sources in the Bear Creek watershed is provided in the supplemental TMDL Implementation Strategies document available online at dnr.mo.gov/env/wpp/tmdl/0115u-01-bear-ck-record.htm.

Table 20. Nonpoint Source Reduction Practices Implemented in the Upper Bear Creek HUC-12

Year	Practice	Sediment and Nutrient Reduction Area (Acres)
2014	Terrace System with Tile	18.70
2015	Water Impoundment Reservoir	11.50
	Sod Waterway	17.90
2016	Cover Crop	241.5
	Sod Waterway	24.80
2018	Water Impoundment Reservoir	6.60
2019	Water Impoundment Reservoir x2	51.30
	Cover Crop	230.3
	Total	602.6

15. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. A 45-day public notice period for this revised TMDL was held from September 27 through November 12, 2019. Comments were received from the City of Kirksville and EPA Region 7. The Department has made all comments received during this period and the Department's responses to those comments available online at dnr.mo.gov/env/wpp/tmdl/0115u-01-bear-ck-record.htm. Groups that directly received notice of the public comment period for this TMDL included, but were not limited to:

- Missouri Clean Water Commission;
- Missouri Water Protection Forum;
- Missouri Department of Conservation;
- County soil and water conservation district;
- County commission;
- Northeast Missouri Regional Planning Commission;
- University of Missouri Extension;
- Missouri Coalition for the Environment;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed;
- Affected permitted entities; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups contacted directly about the public notice, the Department posted this revised TMDL and an implementation strategies document online at dnr.mo.gov/env/wpp/tmdl/0115u-01-bear-ck-record.htm.

The Department also maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

16. Administrative Record and Supporting Documentation

The Department has an administrative record on file for the revised Bear Creek TMDL. The record contains any plans, studies, data, and calculations on which the TMDL is based. It additionally includes the public notice announcement, any public comments received, the Department's responses to those comments and files associated with the development of this revised TMDL and the original 2010 TMDL. This information is available upon request to the Department at dnr.mo.gov/sunshine-form.htm. The Department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the Department's administrative policies and procedures governing Sunshine Law requests. For more information about open record/Sunshine requests, please consult the Department's website at dnr.mo.gov/sunshinerequests.htm.

17. References

Arnold, C.L. and C.J. Gibbons. 1996. Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62.2.

Brown, E., Caraco, D. and R. Pitt. 2004. Illicit Discharge Detection and Elimination a Guidance Manual for Program Development and Technical Assessments. EPA X-82907801-0

Chapman, S.S., Omernik, J.M., Griffith, G.E., Schroeder, W.A., Nigh, T.A., and Wilton, T.F. 2002. Ecoregions of Iowa and Missouri (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,800,000).

Cox, B.A. 2003. A review of dissolved oxygen modelling techniques for lowland rivers. The Science of the Total Environment. 314-316 (2003) 303-334.

DHSS (Missouri Department of Health and Senior Services). 2018. Onsite Wastewater Treatment webpage. [Online WWW] Available URL: health.mo.gov/living/environment/onsite/ [Accessed 15 May 2018].

EPRI (Electric Power Research Institute). 2000. Electric Power Research Institute 2000 Annual Report.

Hobbie, S.E., Finlay, J.C., Janke, B.D., Nidzgorski, D.A., Millet, D.B., and Baker, L.A. 2017. Contrasting nitrogen and phosphorus budgets in urban watersheds and implications for managing urban water pollution. Proceedings of the National Academy of Sciences of the United States of America. 114(16) 4177-4182.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Horsley & Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine.

MDC (Missouri Department of Conservation). 2001. Bear Creek and North Fork Salt River Sampling. Letter and Data Forms. May 24, 2001.

MoRAP (Missouri Resource Assessment Partnership). 2005. A gap analysis for riverine ecosystems of Missouri. Final report, submitted to the USGS national gap analysis program. 1675pp.

NRCS (Natural Resources Conservation Service). 2009. National Engineering Handbook, Part 630 Hydrology, Chapter 7 Hydrologic Soil Groups.

NRCS (Natural Resources Conservation Service). 2017. Web Soil Survey. [Online WWW] Available URL: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm [Accessed 28 May 2019].

NOAA (National Oceanic and Atmospheric Administration). 2010. Climate Normals NOAA Online Weather Data. [Online WWW] Available URL: https://www.ncdc.noaa.gov/cdo-web/ [Accessed 29 May 2019].

Schueler, Tom. 1994. The importance of imperviousness. Watershed Protection Techniques. 1.3.

University of Nebraska. 2019. United States Drought Monitor. The National Drought Mitigation Center. University of Nebraska-Lincoln. Accessed at http://droughtmonitordev.unl.edu/Data.aspx on May 15, 2019.

U.S. Census Bureau (U.S. Department of Commerce). 2010. TIGER/Line Shapefile, 2010, 2010 state, Missouri, 2010 Census Block State-based [ArcView Shapefile].

USEPA (U.S. Environmental Protection Agency). 2000. Ecoregional Criteria. [Online WWW] Available URL: https://www.epa.gov/nutrient-policy-data/ecoregional-criteria [Accessed 28 May 2019].

USEPA (U.S. Environmental Protection Agency). 2014. STEPL Data Server for Sample Input Data. [Online WWW] Available URL: it.tetratech-ffx.com/steplweb/STEPLdataviewer.htm [Accessed 16 May 2018].

USGS (U.S. Geological Survey). 2009. Ecology-Ecological Drainage Units. [Online WWW] Available URL: nh.water.usgs.gov/projects/ct_atlas/tnc_edu.htm [Accessed 7 June 2017].

Appendix A
Support for QUAL2K Model Assumptions

Existing Condition of Bear Creek

A 2001 fishery study, in which the Missouri Department of Conservation (MDC) compared fish species in Bear Creek to those in North Fork Salt River, found that there were reduced numbers of riffle fish species in Bear Creek (MDC 2001). This finding was determined to be evidence of impairments to aquatic life (warm water habitat), and prompted the Department to include Bear Creek on the 2002 Missouri 303(d) List of impaired waters for unknown pollutants from unknown sources. Water quality data collected in July and August 2009 showed that Bear Creek did not meet the minimum water quality criterion of 5.0 mg/L dissolved oxygen in seven out of 55 (12.7 percent) of the samples. Low dissolved oxygen affects biological activity and likely contributes to reduced numbers of riffle fish species in Bear Creek. In addition, benthic macroinvertebrate studies found that Bear Creek was only partially supporting taxa richness and diversity at 3 out of 7 sample sites. Low fish and macroinvertebrate diversity can result from both low dissolved oxygen and poor quality substrate caused by excessive sedimentation.

During the QUAL2K model calibration process it became evident that the Kirksville Wastewater Treatment Facility is not the primary cause of low dissolved oxygen in Bear Creek. When the model was calibrated to align with observed data for dissolved oxygen, the model responded with ammonia nitrogen and biochemical oxygen demand estimates much lower than the concentrations that were observed at stream monitoring points.[15] When the model was calibrated to align with observed data for ammonia nitrogen and biochemical oxygen demand, the model responded with dissolved oxygen concentrations much higher than were observed at in-stream monitoring points. In order to calibrate the model to simultaneously align with observed data for dissolved oxygen, ammonia nitrogen, and biochemical oxygen demand, it was necessary to assign elevated ammonia nitrogen concentrations to incoming tributaries in order to represent nonpoint source loading, as well as assign substantial sediment oxygen demand along the mainstem of Bear Creek. High ammonia nitrogen due to nonpoint source loading from hay and pasture land would result in high sediment oxygen demand, as organic material high in nitrogen would accumulate in the stream bottom from continuous nonpoint source runoff.

In addition to the behavior of the QUAL2K model in relation to observed data, the influence of nonpoint source loading is also evident in the water quality data for Bear Creek. Data for a stream that receives nitrogen from a single point source (e.g., wastewater treatment effluent) typically show a steady and steep decline in ammonia nitrogen concentrations at regular intervals downstream of the point source. This is a result of the process of nitrification where ammonia nitrogen is converted to nitrate and nitrite. Nitrification uses oxygen and results in low dissolved oxygen concentrations when the quantity of nitrogen is extensive enough to require more oxygen for nitrification than can be replenished by reaeration and atmospheric exchange. In a stream influenced solely by nitrogen inputs from a single point source, the data should show an increase in ammonia nitrogen with a corresponding decrease in dissolved oxygen concentrations immediately downstream of the point source. The initial increase in ammonia nitrogen is followed by a steady decline downstream as the ammonia undergoes nitrification. Oxygen demand decreases as nitrification occurs, and this results

[15] When the models were revised in April 2020 in response to EPA comments all values previously input as ammonia nitrogen were instead input as organic nitrogen. This does not change the discussion nor influence model outputs.

in a steady increase in dissolved oxygen concentrations. Data recorded along Bear Creek in July and August 2009 show a significant increase in nitrogen downstream of the Kirksville Wastewater Treatment Facility, but do not show a steady decline in ammonia nitrogen downstream, or the return to concentrations similar to those above the point source. The data also do not show a steady increase in dissolved oxygen concentrations downstream of the facility as would be expected as oxygen demand from the facility effluent decreases through decomposition and reaeration.

Land use in the upper Bear Creek watershed is predominantly hay and pasture (58 percent) which, according to STEPL,[16] contributes twice as much nitrogen via overland runoff (pollutant loading) as cropland, and 20 times that of forestland which is the next most predominant land cover type (14 percent). The predominance of fine-grained erodible soils (silt and loam) in the watershed, their high potential for runoff, the predominance of hay and pasture lands, and the behavior of the QUAL2K model with respect to nitrogen and dissolved oxygen, provide strong evidence that nonpoint source loading is the primary source of pollutants causing the impairment to aquatic life in Bear Creek.

2020 Revised QUAL2K Calibration Model

The QUAL2K model was calibrated to data recorded at seven sample points along Bear Creek on July 15, 2009, and data documented in the discharge monitoring report for the Kirksville Wastewater Treatment Facility on July 30, 2009. Use of the observed data, especially for stream hydrology and from facility records, did not always contribute to a well-calibrated QUAL2K model. Support for adjustments to input data and assumptions used to calibrate the model are presented in the paragraphs below.

Stream Hydrology

Model inputs that inform predicted values for stream flow and velocity were adjusted to provide reasonable portrayals of stream hydrology, while also supporting the calibration of the model to observed dissolved oxygen data. QUAL2K uses fluctuations in stream flow and velocity to inform estimates of reaeration along the stream gradient. When flow and velocity values are high, QUAL2K assumes high reaeration and this results in an overestimation of dissolved oxygen concentrations. In order for the model to accurately portray the observed dissolved oxygen trends, stream hydrology was assumed to be more stable along the stream gradient than was reflected in observed data records. Calibrated stream hydrology trends are explained in the following paragraphs.

Flow

Stream flow is the volume of water in a stream moving past a fixed point in a given period of time and is typically measured as cubic feet per second. These stream flow values are converted to cubic meters per second prior to input into QUAL2K. During model calibration, stream flow was aligned precisely with the observed (and expected) increase in flow immediately downstream of the Kirksville Wastewater Treatment Facility where wastewater effluent volumes contribute substantially to stream volume during summer low flows. Model inputs that influence predicted flow downstream of the facility were adjusted to assume consistent flow as would be expected of streams in northeastern Missouri.

[16] Spreadsheet Tool for Estimating Pollutant Load (http://it.tetratech-ffx.com/steplweb/)

Velocity

Observed data for stream velocity revealed a substantial peak in stream velocity at the discharge point of the Kirksville Wastewater Treatment Facility. Although this may accurately portray the influence of a large volume of effluent entering the stream, QUAL2K treated the velocity increase as an increase in stream base flow and assumed very high reaeration as a result of high velocity. This caused QUAL2K to estimate a substantial increase in dissolved oxygen at the effluent discharge point instead of the sag in dissolved oxygen concentration that would be expected when concentrated ammonia nitrogen and other organic material from effluent enters the stream and exerts a suddenly high oxygen demand. The observed dissolved oxygen data reflect the expected sag. In order to align the predicted dissolved oxygen with the observed data, the influence of effluent discharge on stream velocity was substantially reduced, and the stream was assumed to have stable velocity for the entire downstream distance of the impaired segment.

Bear Creek Mainstem Data

Data recorded on July 15, 2009, were used to calibrate the 2019 revised QUAL2K model. Data were collected on four dates in July and August 2009. Of these four dates, water temperatures were the highest and dissolved oxygen concentrations were the lowest on July 15. For this reason, data from the July 15, 2009, monitoring event were used for model calibration (Table A-1). The sample point locations are presented on Figure A-1. Data recorded at Sample Point 1 were used for the QUAL2K model headwater inputs. All other sample points were used to define the reaches of the stream and to calibrate the model-predicted outputs to observed data.

Table A-1. July 15, 2009 Data Used for 2019 Revised QUAL2K Calibration Model

Sample Point	Time	$CBOD_5$ (mg/L)	Nitrogen (mg/L)	Nitrate (mg/L)	DO (mg/L)	pH	Temp (°C)	TP (mg/L)
1	6:15 am	ND	0.844	0.300	3.98	6.52	23.31	0.102
1	12:55 pm	1.6	0.640	0.281	2.27	7.58	24.22	0.072
2	6:50 am	ND	2.105	11.73	6.15	7.68	23.32	5.20
2	1:50 pm	4.7	2.755	8.67	7.02	7.8	25.48	4.70
4	5:40 am	ND	2.7505	9.24	5.77	7.54	23.10	4.35
4	12:25 pm	5.5	2.371	7.955	5.22	7.61	24.50	4.40
5	5:12 am	ND	1.918	8.31	5.43	7.31	23.40	4.70
5	12:00 pm	4.9	2.243	5.81	3.13	7.61	24.58	3.20
6	6:15 am	ND	2.019	8.34	4.40	7.54	23.39	6.50
6	1:15 pm	3.8	1.512	6.02	7.54	7.75	25.14	4.40
7	5:45 am	ND	1.540	6.59	6.09	7.74	23.61	5.10
7	12:40 pm	4.1	1.6575	7.42	10.77	8.17	25.66	5.20
8	5:05 pm	ND	1.425	5.625	6.07	7.76	23.48	3.60
8	12:02 pm	3.0	1.489	6.22	9.97	8.46	26.19	3.80

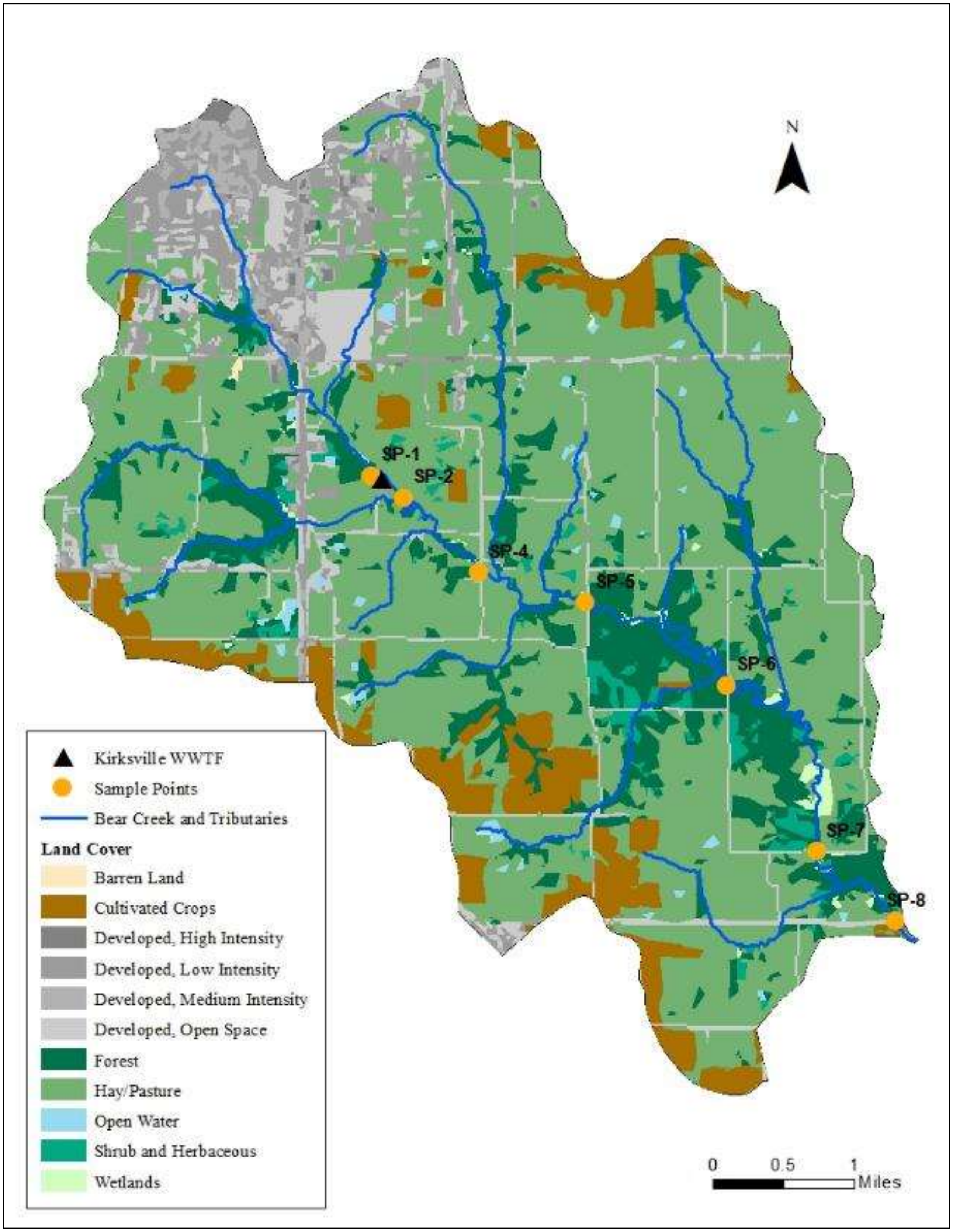

Figure A-1. Locations of Sample Points and Nine Tributaries Used for the QUAL2K Model

Kirksville Wastewater Treatment Facility Inputs

The data recorded for July 2009 in the discharge monitoring report for the Kirksville Wastewater Treatment Facility were initially input to represent the influence of the point source discharge from the facility, and the reported 7.0 mg/L dissolved oxygen concentration was used. However, the facility reported a biochemical oxygen demand value of 18.0 mg/L, and that value resulted in higher biochemical oxygen demand in the model than was reflected in the data observed at Sample Point 2. The biochemical oxygen demand value for the Kirksville Wastewater Treatment Facility was reduced to 6.0 mg/L, and this adjustment resulted in alignment with the biochemical oxygen demand observed in Bear Creek. Temperature, organic phosphorus, and pH data were not recorded in the discharge monitoring report in June 2009, and ammonia nitrogen recorded in June 2009 was lower than that observed at Sample Point 2. Therefore, with the exception of dissolved oxygen and biochemical oxygen demand, data recorded at Sample Point 2 were used to represent the Kirksville Wastewater Treatment Facility effluent values for model calibration.

Burk Subdivision Wastewater Treatment Facility Inputs

The Burk Subdivision Wastewater Treatment Facility is 1.5 miles, and two tributaries, upstream of Bear Creek. Nitrogen and phosphorus do not travel conservatively from facility outfalls to downstream locations. Nitrogen undergoes a continuous process of transformation from $NH_4 \rightarrow NO_3/NO_2 \rightarrow N_2$ (gas) that returns to the atmosphere. Phosphorus adheres to soil particles in receiving streams resulting in reduced concentrations downstream. Therefore, in order to determine the nitrogen and phosphorus contributions from the Burk Subdivision Wastewater Treatment Facility to Bear Creek, it was necessary to estimate the rate at which nutrients are assimilated by the receiving tributaries over 1.5 miles. Percent loss of TN and TP was estimated using sample data taken in a tributary to Middle Fork Salt River downstream of the Macon Wastewater Treatment Facility. The Macon facility is located approximately 29 miles south of the Burk Subdivision Wastewater Treatment Facility in an adjacent 8-digit HUC watershed (07110006). Land use, climate, and geology downstream of the Macon facility are comparable to that downstream of the Burk Subdivision Wastewater Treatment Facility, making it an appropriate representation of nutrient loss kinetics in the Bear Creek watershed. The measured percent loss of TN and TP over distance from the Macon facility for 1.5 miles downstream was applied to the Burk Subdivision Wastewater Treatment Facility to account for incremental loss of nutrients. The resulting nitrogen and phosphorus values were input into the QUAL2K model.

Tributary Inputs

As previously explained, the significant impact that nonpoint source pollutants have on Bear Creek became evident during the model calibration process. Model-predicted outputs did not align with observed data when the Kirksville Wastewater Treatment Facility was assumed to be the primary influence on the chemistry of Bear Creek. In order to align the model outputs with observed data, nine tributaries were added to the Point Source tab of the QUAL2K model. There are no observed data for any of the tributaries. Flow volumes, dissolved oxygen, biochemical oxygen demand, nitrogen, and phosphorus values were assigned to the tributaries and were adjusted so that the dissolved oxygen, biochemical oxygen demand, ammonia nitrogen, and organic phosphorus outputs would all simultaneously align with the trend of the observed data. The values assigned to tributaries are estimates used to generally account for nonpoint source inputs in order to develop a strongly calibrated model, but may not reflect the actual characteristics of each tributary. The methodology used to derive the load allocation designated to nonpoint sources is explained in

Section 10 of the 2019 Revised TMDL. The values assigned to the tributaries are presented in Table A-2.

Table A-2. Point Source and Tributary Values Used to Calibrate the QUAL2K Model[17]

	Flow (cms)	Temp. (°C)	CBOD (mg/L)	DO (mg/L)	Organic N (ug/L)	Organic P (ug/L)
Kirksville WWTF	0.0690	24.22	6.00	7.00	3120.00	520.00
Burk WWTF	0.0090	22.00	5.50	5.00	460.00	100.00
Tributary 2	0.0150	25.48	5.50	2.00	1855.00	100.00
Tributary 3	0.0100	24.50	6.00	2.00	3255.00	100.00
Tributary 4	0.0001	24.50	6.00	2.00	3255.00	100.00
Tributary 5	0.0001	24.58	6.00	2.00	4255.00	100.00
Tributary 6	0.0000	24.58	6.00	2.00	4255.00	500.00
Tributary 7	0.0001	25.14	7.00	2.00	4255.00	600.00
Tributary 8	0.0001	25.14	7.00	2.00	2255.00	100.00
Tributary 9	0.0060	25.66	4.00	2.00	5255.00	100.00
Tributary 10	0.0020	26.19	4.00	2.00	5255.00	100.00

Final Calibration Adjustments

Tributary model inputs were adjusted so that the model-predicted organic nitrogen and phosphorus concentrations aligned well with the observed data. However, QUAL2K model predictions still overestimated dissolved oxygen and underestimated biochemical oxygen demand. Benthic (bottom) algae percent cover was adjusted to capture the morning low and afternoon high dissolved oxygen concentrations recorded in the observed data. The percent cover of sediment oxygen demand, which represents organic material in the streambed that exerts oxygen demand for decomposition, was increased to 80 percent in the stream reach immediately downstream of the Kirksville Wastewater Treatment Facility, and 100 percent in the remaining downstream reaches. Following these adjustments, QUAL2K still overestimated dissolved oxygen concentrations along the stream gradient. Prescribed sediment oxygen demand values were then assigned to further lower the model-predicted dissolved oxygen values. This adjustment resulted in close alignment of the model-predicted dissolved oxygen with the observed data. As discussed previously in the "Existing Condition" section, accumulation of organic material from nonpoint source inputs would result in high sediment oxygen demand in Bear Creek. The results of the QUAL2K model calibration are presented in Figures A-1 through A-3.

[17] The tributaries are labeled as presented in the QUAL2K model. The first tributary in the model is the Kirksville Wastewater Treatment Facility so the tributary numbering begins at No. 2.

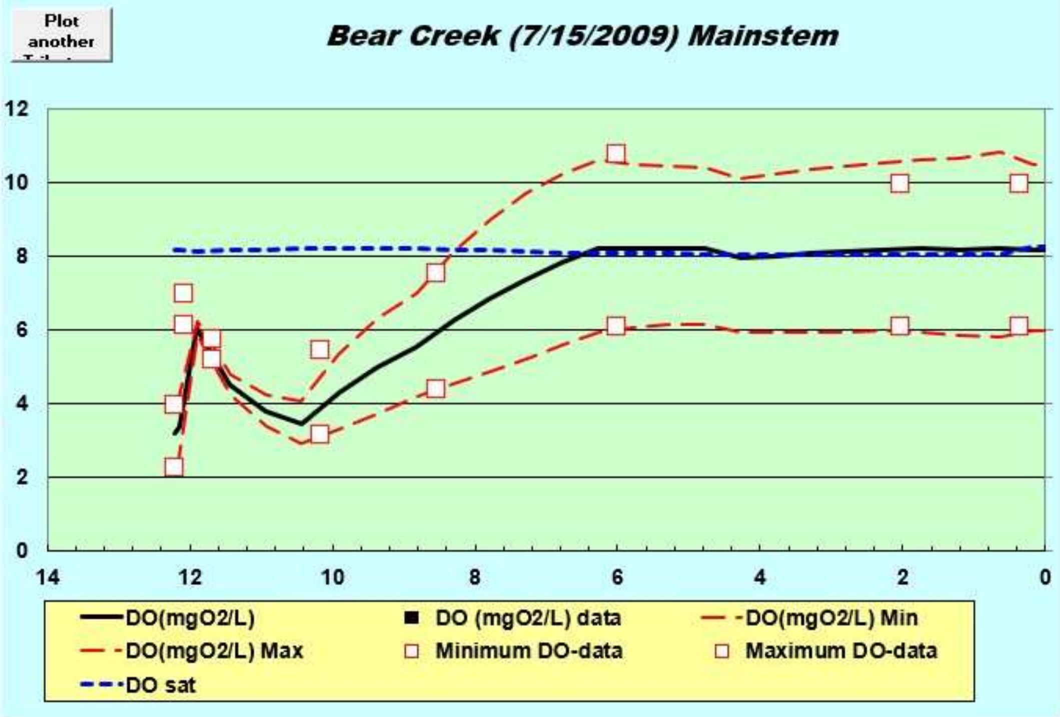

Figure A-1. QUAL2K Calibration Model – Dissolved Oxygen

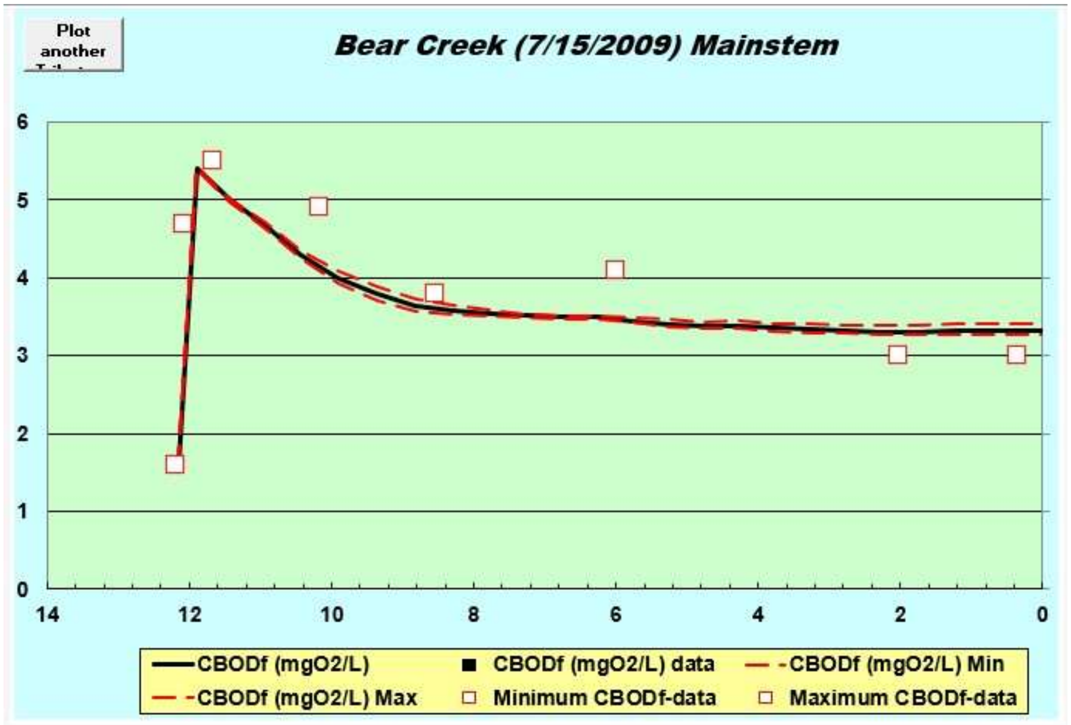

Figure A-2. QUAL2K Calibration Model – Biochemical Oxygen Demand

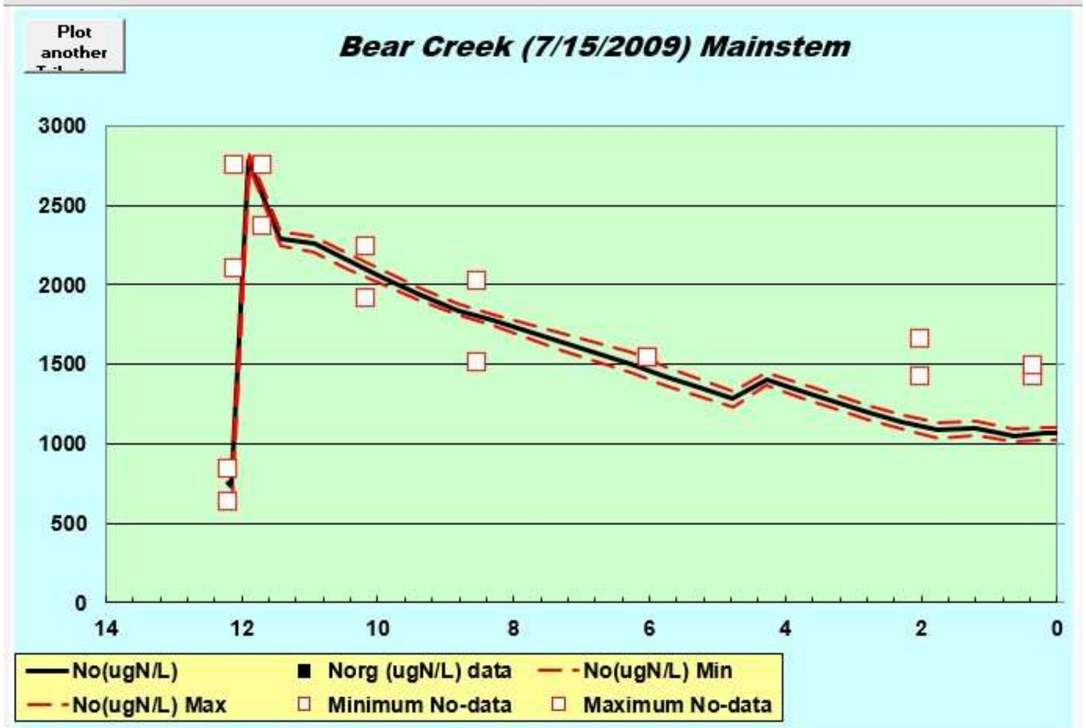

Figure A-3. QUAL2K Calibration Model – Organic Nitrogen

2019 TMDL Load Capacity QUAL2K Model under Low-Flow Condition

A second QUAL2K model was developed to demonstrate the water quality improvements that will result from reductions in nonpoint source loading and improvements to wastewater effluent from the Kirksville Wastewater Treatment Facility. The RTAG values were used for QUAL2K Headwater inputs because low dissolved oxygen upstream of the Kirksville Wastewater Treatment Facility is addressed in the wasteload allocations assigned to the Kirksville MS4 in the 2019 Revised TMDL. The load capacity model is designed to reflect critical low flow conditions as determined by 7Q10 low flow volumes. Flow volume inputs for the Bear Creek headwater and ten tributaries were obtained from the USGS StreamStats online tool. The four million gallon per day (MGD) design flow of the Kirksville Wastewater Treatment Facility was used to represent the maximum influence the wastewater effluent may have on Bear Creek. Because the water quality of Bear Creek is primarily influenced by nonpoint sources, it was necessary to reduce the nitrogen, phosphorus, and biochemical oxygen demand of the tributaries to accurately depict the condition of Bear Creek following implementation of both point and nonpoint source load reductions. The nitrogen, phosphorus, and biochemical oxygen demand concentrations were reduced by 30 percent, and the percent coverage of benthic algae and sediment oxygen demand were also reduced by 30 percent to reflect the corresponding reduction. The input values are presented in Table A-3.

Table A-3. Input Values for Point Source and Tributaries for the Load Capacity Model

	Flow (cms)	Temp. (°C)	CBOD (mg/L)	DO (mg/L)	Organic N (ug/L)	Organic P (ug/L)
Kirksville WWTF	0.1753	24.22	6.50	6.00	1000.00	500.00
Burk WWTF	0.0090	22.00	5.50	5.00	460.00	75.00
Tributary 2	0.000025	25.48	3.85	5.00	1298.50	75.00
Tributary 3	0.000001	24.50	4.20	5.00	2278.50	75.00
Tributary 4	0.000021	24.50	4.20	5.00	2278.50	75.00
Tributary 5	0.000001	24.58	4.20	5.00	2978.50	75.00
Tributary 6	0.000012	24.58	4.20	5.00	2978.50	350.00
Tributary 7	0.000001	25.14	4.90	5.00	2978.50	420.00
Tributary 8	0.000009	25.14	4.90	5.00	1578.50	75.00
Tributary 9	0.000023	25.66	2.80	5.00	3678.50	75.00
Tributary 10	0.000013	26.19	2.80	5.00	3678.50	75.00

As presented in Table A-4, the load capacity QUAL2K model demonstrates that under critical low-flows, when the Kirksville Wastewater Treatment Facility contributes the majority of water to Bear Creek, the reduced loading from point and nonpoint sources will result in attainment of water quality standards.

Table A-4. QUAL2K Dissolved Oxygen with Kirksville WLAs and 30 percent NPS Reductions

End of Reach	DO concentration (mg/L)
2*	5.37
3	5.93
4	6.63
5	6.93
6	6.86
7	6.96
8	6.96

Appendix B
Total Suspended Solids Load Duration Curve Development

Overview
The load duration curve approach was used to develop the total suspended solids TMDL for Bear Creek. The load duration curve method allows for characterizing water quality concentrations at different flow regimes and estimating the load allocations and wasteload allocations for the impaired segment. This method also provides a visual display of the relationship between stream flow and loading capacity. Using the duration curve framework, allowable loadings are easily presented.

Methodology
The load duration curve method requires a long-term time series of daily flows and a numeric water quality target (typically the applicable numeric criterion or a surrogate when addressing general criteria). When available, pollutant data from the impaired segment is used to provide estimates of observed loads (based on flow estimates for the same date) and are plotted along with the load duration curve to assess when the water quality target may have been exceeded. Such information is useful for determining appropriate best management practices to reduce pollutant loading.

To develop a load duration curve, the average daily flow data from a gage or multiple gages that are representative of the impaired reach are used. The flow record should be of sufficient length to be able to calculate percentiles of flow. If a flow record for an impaired stream is not available, then flow data collected from a gage in a representative watershed may be used or a synthetic flow record from several gages can be developed. For Bear Creek, a synthetic flow record was developed using the log discharge per square mile of USGS gages from streams within the same EDU. For this TMDL, six gages with sufficient flow records were used to develop a synthetic flow (Table B1). For each gage flow record used to develop the synthetic flow, Nash-Sutcliffe statistics are calculated to determine if the relationship is valid for each record. The Nash-Sutcliffe statistic evaluates the efficiency of a predicted (modeled) flow dataset (Nash and Sutcliffe 1970). An efficiency of 1 (100 percent) describes a perfect match, while values less than zero indicate a poor fit of modeled and observed datasets (USGS 2010). This relationship must be valid in order to use the synthetic flow methodology. Model estimates are considered satisfactory if Nash-Sutcliffe statistics are greater than 50 percent (USGS 2013).

Figures B1 presents the synthesized flow duration curve developed for the EDU. Figure B2 is the estimated flow for Bear Creek based on the area corrected synthesized flow and point source design flow discharges added. The estimated flows for Bear Creek, in units of cubic feet per second, were multiplied by the concentration target of 15 mg/L and a conversion factor of 5.394 in order to generate the allowable total suspended solids load in units of lbs/day.[18] To derive the static wasteload allocation assigned to the Kirksville Wastewater Treatment Facility, the concentration target and the Facility’s upgraded design flow were used. Wasteload allocations to the Kirskville MS4 are based on the proportion of municipal area in the watershed and vary with flow. Selection of the target concentration used a reference approach and was derived as the 25th percentile of all total suspended solids data in the EDU and provides an implicit margin of safety (Table B2). The load allocation assigned to nonpoint sources is calculated as the remainder of the loading capacity

[18] $Load\ \left(\frac{\text{lbs}}{\text{day}}\right) = \left[Target\left(\frac{\text{mg}}{\text{100ml}}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right)\right] * [Conversion\ Factor]$

after allocations to point sources and the margin of safety. Nonpoint sources are not expected to contribute pollutant loading during critical low flow conditions, therefore load allocations to nonpoint sources at these low flows will likely provide an additional implicit margin of safety.

It should be noted that the gages used for this revised TMDL were the same as those used in the original Bear Creek TMDL established by EPA on December 23, 2010. However, for this revised TMDL more recent flow data were used (October 1, 1998 through June 3, 2019). Flow data that were in provisional status at the time of this report were not used.

Table B1. Stream gages used to develop synthetic flow for Bear Creek

USGS Gage	Drainage Area (mi^2)	Period of Data	Nash-Sutcliff (%)
05495000 Fox River at Wayland, MO	400	10/1/1998 to 5/28/2019	74
05502300 North Fork Salt River at Hagers Grove, MO	365	10/1/1998 to 6/3/2019	58
05506800 Elk Fork Salt River near Madison, MO	200	10/1/1998 to 6/2/2019	62
05500000 South Fabius River near Taylor, MO	620	10/1/1998 to 3/26/2019	97
05496000 Wyaconda River above Canton, MO	393	10/1/1998 to 5/22/2019	98
05498000 Middle Fabius River near Monticello, MO	393	10/1/1998 to 9/29/2005	92
		Mean:	**80**

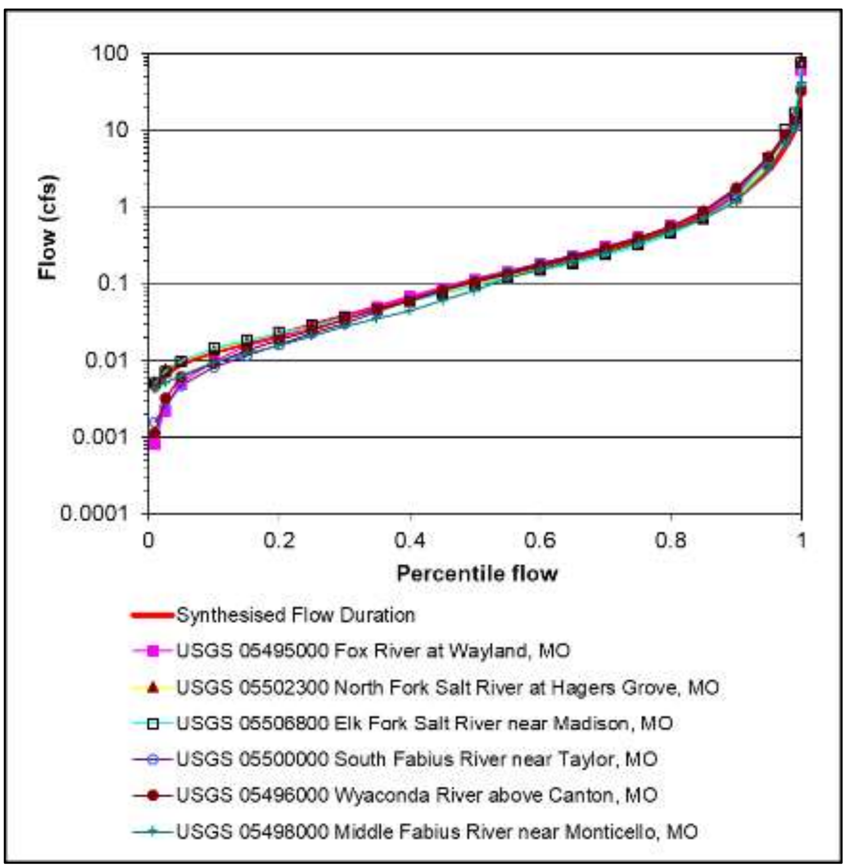

Figure B1. EDU flow duration curve

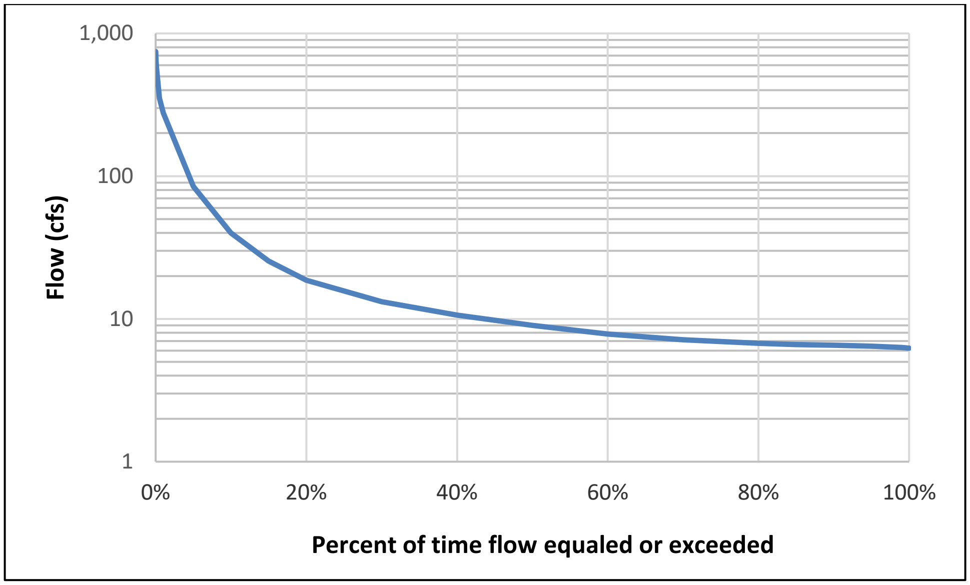

Figure B2. Bear Creek flow duration curve

Table B2. USGS total suspended solids data used to develop TMDL target (sorted by date)

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	11/8/1989	Grab	51
593/36.0	Grand R. @ Sumner	1/18/1990	Grab	252
593/36.0	Grand R. @ Sumner	5/9/1990	Grab	586
593/36.0	Grand R. @ Sumner	7/11/1990	Grab	439
593/36.0	Grand R. @ Sumner	11/7/1990	Grab	215
593/36.0	Grand R. @ Sumner	1/9/1991	Grab	19
593/36.0	Grand R. @ Sumner	5/17/1991	Grab	1700
593/36.0	Grand R. @ Sumner	7/16/1991	Grab	568
593/36.0	Grand R. @ Sumner	11/6/1991	Grab	237
593/36.0	Grand R. @ Sumner	1/15/1992	Grab	384
593/36.0	Grand R. @ Sumner	7/8/1992	Grab	75
593/36.0	Grand R. @ Sumner	11/12/1992	Grab	2300
593/36.0	Grand R. @ Sumner	4/8/1993	Grab	10000
593/36.0	Grand R. @ Sumner	1/5/1995	Grab	25
593/36.0	Grand R. @ Sumner	3/30/1995	Grab	1450
593/36.0	Grand R. @ Sumner	6/14/1995	Grab	571
593/36.0	Grand R. @ Sumner	9/5/1995	Grab	84
593/36.0	Grand R. @ Sumner	11/17/1997	Grab	6
593/36.0	Grand R. @ Sumner	1/15/1998	Grab	16
550/17.7	No Cr. Nr. Dunlap	1/22/1998	Grab	1
623/14.2	L. Medicine Cr. @Hwy E	1/22/1998	Grab	1
674/28.8	Mussel Fk. nr. Mystic	1/23/1998	Grab	12
550/17.7	No Cr. Nr. Dunlap	6/2/1998	Grab	51

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
623/14.2	L. Medicine Cr. @Hwy E	6/2/1998	Grab	26
674/28.8	Mussel Fk. nr. Mystic	6/3/1998	Grab	22
593/36.0	Grand R. @ Sumner	6/9/1998	Grab	452
593/36.0	Grand R. @ Sumner	8/18/1998	Grab	60
593/36.0	Grand R. @ Sumner	11/16/1998	Grab	264
623/14.2	L. Medicine Cr. @Hwy E	1/5/1999	Grab	5
674/28.8	Mussel Fk. nr. Mystic	1/6/1999	Grab	4
593/36.0	Grand R. @ Sumner	1/25/1999	Grab	231
593/36.0	Grand R. @ Sumner	6/15/1999	Grab	1800
550/17.7	No Cr. Nr. Dunlap	6/21/1999	Grab	70
623/14.2	L. Medicine Cr. @Hwy E	6/22/1999	Grab	30
674/28.8	Mussel Fk. nr. Mystic	6/23/1999	Grab	47
593/36.0	Grand R. @ Sumner	8/10/1999	Grab	80
549/49.6	Thompson R. at Mt. Moriah	11/9/1999	Grab	527
550/17.7	No Cr. Nr. Dunlap	11/29/1999	Grab	73
593/36.0	Grand R. @ Sumner	11/30/1999	Grab	10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/30/1999	Grab	6
623/14.2	L. Medicine Cr. @Hwy E	11/30/1999	Grab	1
674/28.8	Mussel Fk. nr. Mystic	11/30/1999	Grab	11
593/36.0	Grand R. @ Sumner	1/4/2000	Grab	16
550/17.7	No Cr. Nr. Dunlap	1/24/2000	Grab	28
674/28.8	Mussel Fk. nr. Mystic	1/24/2000	Grab	24
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/25/2000	Grab	3
623/14.2	L. Medicine Cr. @Hwy E	1/25/2000	Grab	4
593/36.0	Grand R. @ Sumner	5/2/2000	Grab	95
550/17.7	No Cr. Nr. Dunlap	5/9/2000	Grab	54
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/10/2000	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	5/10/2000	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	5/11/2000	Grab	<10
560/29.0	Weldon R. nr. Princeton	5/16/2000	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	5/18/2000	Grab	27
593/36.0	Grand R. @ Sumner	7/11/2000	Grab	180
550/17.7	No Cr. Nr. Dunlap	7/25/2000	Grab	45
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/26/2000	Grab	37
623/14.2	L. Medicine Cr. @Hwy E	7/26/2000	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	7/27/2000	Grab	10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/14/2000	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/14/2000	Grab	<10
550/17.7	No Cr. Nr. Dunlap	11/15/2000	Grab	21
674/28.8	Mussel Fk. nr. Mystic	11/15/2000	Grab	<10
593/36.0	Grand R. @ Sumner	11/21/2000	Grab	12

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	11/28/2000	Grab	<10
560/29.0	Weldon R. nr. Princeton	11/30/2000	Grab	<10
593/36.0	Grand R. @ Sumner	1/3/2001	Grab	<10
550/17.7	No Cr. Nr. Dunlap	1/24/2001	Grab	18
674/28.8	Mussel Fk. nr. Mystic	1/24/2001	Grab	10
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/25/2001	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/25/2001	Grab	<10
593/36.0	Grand R. @ Sumner	5/1/2001	Grab	90
549/49.6	Thompson R. at Mt. Moriah	5/2/2001	Grab	156
560/29.0	Weldon R. nr. Princeton	5/2/2001	Grab	119
550/17.7	No Cr. Nr. Dunlap	5/22/2001	Grab	41
674/28.8	Mussel Fk. nr. Mystic	5/23/2001	Grab	11
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/24/2001	Grab	68
623/14.2	L. Medicine Cr. @Hwy E	5/24/2001	Grab	31
593/36.0	Grand R. @ Sumner	7/10/2001	Grab	174
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/25/2001	Grab	1610
623/14.2	L. Medicine Cr. @Hwy E	7/25/2001	Grab	444
550/17.7	No Cr. Nr. Dunlap	7/26/2001	Grab	290
674/28.8	Mussel Fk. nr. Mystic	7/26/2001	Grab	228
593/36.0	Grand R. @ Sumner	10/17/2001	Grab	555
550/17.7	No Cr. Nr. Dunlap	10/23/2001	Grab	386
674/28.8	Mussel Fk. nr. Mystic	10/24/2001	Grab	50
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/25/2001	Grab	118
623/14.2	L. Medicine Cr. @Hwy E	10/25/2001	Grab	54
560/29.0	Weldon R. nr. Princeton	11/6/2001	Grab	18
593/36.0	Grand R. @ Sumner	11/6/2001	Grab	18
549/49.6	Thompson R. at Mt. Moriah	11/8/2001	Grab	14
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/28/2001	Grab	12
623/14.2	L. Medicine Cr. @Hwy E	11/28/2001	Grab	<10
550/17.7	No Cr. Nr. Dunlap	11/29/2001	Grab	78
674/28.8	Mussel Fk. nr. Mystic	11/29/2001	Grab	<10
593/36.0	Grand R. @ Sumner	12/4/2001	Grab	16
623/14.2	L. Medicine Cr. @Hwy E	12/12/2001	Grab	<10
550/17.7	No Cr. Nr. Dunlap	12/13/2001	Grab	18
674/28.8	Mussel Fk. nr. Mystic	12/13/2001	Grab	20
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/3/2002	Grab	<10
593/36.0	Grand R. @ Sumner	1/8/2002	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/8/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/8/2002	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	1/9/2002	Grab	10
560/29.0	Weldon R. nr. Princeton	1/15/2002	Grab	<10

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	1/17/2002	Grab	<10
593/36.0	Grand R. @ Sumner	2/5/2002	Grab	12
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/27/2002	Grab	12
623/14.2	L. Medicine Cr. @Hwy E	2/27/2002	Grab	<10
550/17.7	No Cr. Nr. Dunlap	2/28/2002	Grab	22
674/28.8	Mussel Fk. nr. Mystic	2/28/2002	Grab	18
593/36.0	Grand R. @ Sumner	3/6/2002	Grab	12
560/29.0	Weldon R. nr. Princeton	3/12/2002	Grab	114
549/49.6	Thompson R. at Mt. Moriah	3/14/2002	Grab	43
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/19/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	3/19/2002	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	3/20/2002	Grab	<10
550/17.7	No Cr. Nr. Dunlap	3/21/2002	Grab	<10
593/36.0	Grand R. @ Sumner	4/10/2002	Grab	1440
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/17/2002	Grab	130
623/14.2	L. Medicine Cr. @Hwy E	4/17/2002	Grab	66
550/17.7	No Cr. Nr. Dunlap	4/18/2002	Grab	36
674/28.8	Mussel Fk. nr. Mystic	4/18/2002	Grab	17
560/29.0	Weldon R. nr. Princeton	5/7/2002	Grab	210
593/36.0	Grand R. @ Sumner	5/7/2002	Grab	2420
549/49.6	Thompson R. at Mt. Moriah	5/9/2002	Grab	347
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/21/2002	Grab	38
623/14.2	L. Medicine Cr. @Hwy E	5/21/2002	Grab	14
674/28.8	Mussel Fk. nr. Mystic	5/22/2002	Grab	20
550/17.7	No Cr. Nr. Dunlap	5/23/2002	Grab	<10
550/17.7	No Cr. Nr. Dunlap	6/13/2002	Grab	20
674/28.8	Mussel Fk. nr. Mystic	6/27/2002	Grab	11
550/17.7	No Cr. Nr. Dunlap	6/28/2002	Grab	40
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/28/2002	Grab	13
623/14.2	L. Medicine Cr. @Hwy E	6/28/2002	Grab	<10
593/36.0	Grand R. @ Sumner	7/16/2002	Grab	145
550/17.7	No Cr. Nr. Dunlap	7/23/2002	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/24/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	7/24/2002	Grab	<10
560/29.0	Weldon R. nr. Princeton	7/30/2002	Grab	14
549/49.6	Thompson R. at Mt. Moriah	8/1/2002	Grab	22
593/36.0	Grand R. @ Sumner	8/13/2002	Grab	<10
560/29.0	Weldon R. nr. Princeton	8/15/2002	Grab	20
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/21/2002	Grab	41
623/14.2	L. Medicine Cr. @Hwy E	8/21/2002	Grab	<10
550/17.7	No Cr. Nr. Dunlap	8/22/2002	Grab	44

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	8/22/2002	Grab	22
549/49.6	Thompson R. at Mt. Moriah	9/3/2002	Grab	176
593/36.0	Grand R. @ Sumner	9/4/2002	Grab	65
560/29.0	Weldon R. nr. Princeton	9/5/2002	Grab	13
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/10/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	9/10/2002	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/17/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	10/17/2002	Grab	<10
593/36.0	Grand R. @ Sumner	10/22/2002	Grab	39
560/29.0	Weldon R. nr. Princeton	10/24/2002	Grab	<10
560/29.0	Weldon R. nr. Princeton	11/5/2002	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	11/7/2002	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/19/2002	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/19/2002	Grab	<10
593/36.0	Grand R. @ Sumner	11/27/2002	Grab	10
560/29.0	Weldon R. nr. Princeton	12/10/2002	Grab	<10
593/36.0	Grand R. @ Sumner	12/12/2002	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/18/2002	FieldDupl	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/18/2002	FieldDupl	<10
623/14.2	L. Medicine Cr. @Hwy E	12/18/2002	Grab	<10
550/17.7	No Cr. Nr. Dunlap	12/19/2002	Grab	37
560/29.0	Weldon R. nr. Princeton	1/14/2003	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	1/15/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/29/2003	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/30/2003	Grab	<10
593/36.0	Grand R. @ Sumner	2/12/2003	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/20/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	2/20/2003	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	2/21/2003	Grab	<10
593/36.0	Grand R. @ Sumner	2/25/2003	Grab	<10
560/29.0	Weldon R. nr. Princeton	3/7/2003	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/12/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	3/12/2003	Grab	<10
550/17.7	No Cr. Nr. Dunlap	3/13/2003	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	3/13/2003	Grab	37
674/28.8	Mussel Fk. nr. Mystic	3/19/2003	Grab	14
550/17.7	No Cr. Nr. Dunlap	3/20/2003	Grab	12
593/36.0	Grand R. @ Sumner	3/21/2003	Grab	29
560/29.0	Weldon R. nr. Princeton	3/26/2003	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	3/28/2003	Grab	11
593/36.0	Grand R. @ Sumner	4/11/2003	Grab	46

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/23/2003	Grab	12
623/14.2	L. Medicine Cr. @Hwy E	4/23/2003	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	4/24/2003	Grab	26
550/17.7	No Cr. Nr. Dunlap	4/25/2003	Grab	82
550/17.7	No Cr. Nr. Dunlap	4/30/2003	Grab	12
674/28.8	Mussel Fk. nr. Mystic	4/30/2003	Grab	32
593/36.0	Grand R. @ Sumner	5/2/2003	Grab	524
550/17.7	No Cr. Nr. Dunlap	5/6/2003	Grab	164
674/28.8	Mussel Fk. nr. Mystic	5/7/2003	Grab	44
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/8/2003	Grab	104
623/14.2	L. Medicine Cr. @Hwy E	5/8/2003	Grab	127
560/29.0	Weldon R. nr. Princeton	5/20/2003	Grab	264
549/49.6	Thompson R. at Mt. Moriah	5/22/2003	Grab	107
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/11/2003	Grab	282
623/14.2	L. Medicine Cr. @Hwy E	6/11/2003	Grab	344
550/17.7	No Cr. Nr. Dunlap	6/12/2003	Grab	68
674/28.8	Mussel Fk. nr. Mystic	6/12/2003	Grab	18
593/36.0	Grand R. @ Sumner	6/20/2003	Grab	111
550/17.7	No Cr. Nr. Dunlap	7/9/2003	Grab	43
674/28.8	Mussel Fk. nr. Mystic	7/9/2003	Grab	11
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/10/2003	Grab	161
623/14.2	L. Medicine Cr. @Hwy E	7/10/2003	Grab	2060
549/49.6	Thompson R. at Mt. Moriah	7/15/2003	Grab	96
560/29.0	Weldon R. nr. Princeton	7/17/2003	Grab	19
593/36.0	Grand R. @ Sumner	7/29/2003	Grab	19
593/36.0	Grand R. @ Sumner	8/21/2003	Grab	80
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/25/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	8/25/2003	Grab	13
549/49.6	Thompson R. at Mt. Moriah	8/29/2003	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	9/4/2003	Grab	146
560/29.0	Weldon R. nr. Princeton	9/5/2003	Grab	52
593/36.0	Grand R. @ Sumner	9/9/2003	Grab	58
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/17/2003	Grab	49
674/28.8	Mussel Fk. nr. Mystic	9/17/2003	Grab	18
623/14.2	L. Medicine Cr. @Hwy E	9/18/2003	Grab	20
550/17.7	No Cr. Nr. Dunlap	9/19/2003	Grab	144
593/36.0	Grand R. @ Sumner	10/21/2003	Grab	44
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/22/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	10/22/2003	Grab	<10
550/17.7	No Cr. Nr. Dunlap	10/23/2003	Grab	70
549/49.6	Thompson R. at Mt. Moriah	11/4/2003	Grab	644

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	11/5/2003	Grab	26
560/29.0	Weldon R. nr. Princeton	11/6/2003	Grab	120
550/17.7	No Cr. Nr. Dunlap	11/18/2003	Grab	23
674/28.8	Mussel Fk. nr. Mystic	11/19/2003	Grab	38
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/20/2003	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/20/2003	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/10/2003	Grab	692
623/14.2	L. Medicine Cr. @Hwy E	12/10/2003	Grab	470
550/17.7	No Cr. Nr. Dunlap	12/11/2003	Grab	120
674/28.8	Mussel Fk. nr. Mystic	12/11/2003	Grab	84
593/36.0	Grand R. @ Sumner	12/15/2003	Grab	89
593/36.0	Grand R. @ Sumner	1/7/2004	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/7/2004	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/7/2004	Grab	16
550/17.7	No Cr. Nr. Dunlap	1/8/2004	Grab	17
674/28.8	Mussel Fk. nr. Mystic	1/8/2004	Grab	19
560/29.0	Weldon R. nr. Princeton	1/21/2004	Grab	19
549/49.6	Thompson R. at Mt. Moriah	1/23/2004	Grab	<10
593/36.0	Grand R. @ Sumner	2/3/2004	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	2/20/2004	Grab	81
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/26/2004	Grab	66
623/14.2	L. Medicine Cr. @Hwy E	2/26/2004	Grab	36
550/17.7	No Cr. Nr. Dunlap	2/27/2004	Grab	14
593/36.0	Grand R. @ Sumner	3/2/2004	Grab	112
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/16/2004	Grab	64
623/14.2	L. Medicine Cr. @Hwy E	3/16/2004	Grab	56
674/28.8	Mussel Fk. nr. Mystic	3/17/2004	Grab	60
550/17.7	No Cr. Nr. Dunlap	3/18/2004	Grab	117
560/29.0	Weldon R. nr. Princeton	3/23/2004	Grab	39
549/49.6	Thompson R. at Mt. Moriah	3/25/2004	Grab	186
593/36.0	Grand R. @ Sumner	4/6/2004	Grab	141
550/17.7	No Cr. Nr. Dunlap	4/20/2004	Grab	33
674/28.8	Mussel Fk. nr. Mystic	4/21/2004	Grab	15
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/22/2004	Grab	12
623/14.2	L. Medicine Cr. @Hwy E	4/22/2004	Grab	<10
550/17.7	No Cr. Nr. Dunlap	5/11/2004	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	5/12/2004	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/13/2004	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	5/13/2004	Grab	101
560/29.0	Weldon R. nr. Princeton	5/18/2004	Grab	267
593/36.0	Grand R. @ Sumner	5/19/2004	Grab	1070

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	5/20/2004	Grab	593
550/17.7	No Cr. Nr. Dunlap	6/22/2004	Grab	49
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/23/2004	Grab	49
623/14.2	L. Medicine Cr. @Hwy E	6/23/2004	Grab	33
674/28.8	Mussel Fk. nr. Mystic	6/24/2004	Grab	31
593/36.0	Grand R. @ Sumner	6/28/2004	Grab	158
560/29.0	Weldon R. nr. Princeton	7/7/2004	Grab	14
549/49.6	Thompson R. at Mt. Moriah	7/9/2004	Grab	17
674/28.8	Mussel Fk. nr. Mystic	7/13/2004	Grab	52
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/14/2004	Grab	76
623/14.2	L. Medicine Cr. @Hwy E	7/14/2004	Grab	37
593/36.0	Grand R. @ Sumner	7/15/2004	Grab	475
550/17.7	No Cr. Nr. Dunlap	7/16/2004	Grab	23
593/36.0	Grand R. @ Sumner	8/16/2004	Grab	49
550/17.7	No Cr. Nr. Dunlap	8/23/2004	Grab	67
674/28.8	Mussel Fk. nr. Mystic	8/24/2004	FieldDupl	15
674/28.8	Mussel Fk. nr. Mystic	8/24/2004	FieldDupl	15
674/28.8	Mussel Fk. nr. Mystic	8/24/2004	FieldDupl	21
674/28.8	Mussel Fk. nr. Mystic	8/24/2004	FieldDupl	21
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/25/2004	Grab	1700
623/14.2	L. Medicine Cr. @Hwy E	8/25/2004	Grab	1395
593/36.0	Grand R. @ Sumner	9/2/2004	Grab	543
560/29.0	Weldon R. nr. Princeton	9/8/2004	Grab	85
549/49.6	Thompson R. at Mt. Moriah	9/10/2004	Grab	82
550/17.7	No Cr. Nr. Dunlap	9/14/2004	Grab	520
674/28.8	Mussel Fk. nr. Mystic	9/15/2004	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/16/2004	Grab	15
623/14.2	L. Medicine Cr. @Hwy E	9/16/2004	Grab	64
593/36.0	Grand R. @ Sumner	10/12/2004	Grab	132
550/17.7	No Cr. Nr. Dunlap	10/26/2004	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/27/2004	Grab	131
623/14.2	L. Medicine Cr. @Hwy E	10/27/2004	Grab	146
674/28.8	Mussel Fk. nr. Mystic	10/28/2004	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	11/8/2004	Grab	132
593/36.0	Grand R. @ Sumner	11/9/2004	Grab	56
560/29.0	Weldon R. nr. Princeton	11/10/2004	Grab	<10
550/17.7	No Cr. Nr. Dunlap	11/16/2004	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	11/17/2004	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/18/2004	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/18/2004	Grab	10
593/36.0	Grand R. @ Sumner	12/1/2004	Grab	22

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
550/17.7	No Cr. Nr. Dunlap	12/14/2004	Grab	18
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/16/2004	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	12/17/2004	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	12/17/2004	Grab	<10
560/29.0	Weldon R. nr. Princeton	1/19/2005	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	1/21/2005	Grab	<10
593/36.0	Grand R. @ Sumner	1/24/2005	Grab	90
550/17.7	No Cr. Nr. Dunlap	1/25/2005	Grab	20
674/28.8	Mussel Fk. nr. Mystic	1/26/2005	Grab	46
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/27/2005	Grab	280
623/14.2	L. Medicine Cr. @Hwy E	1/27/2005	Grab	51
674/28.8	Mussel Fk. nr. Mystic	2/8/2005	Grab	65
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/9/2005	Grab	165
550/17.7	No Cr. Nr. Dunlap	2/10/2005	Grab	138
623/14.2	L. Medicine Cr. @Hwy E	2/10/2005	Grab	48
593/36.0	Grand R. @ Sumner	2/14/2005	Grab	2160
560/29.0	Weldon R. nr. Princeton	3/1/2005	Grab	51
549/49.6	Thompson R. at Mt. Moriah	3/3/2005	Grab	42
593/36.0	Grand R. @ Sumner	3/8/2005	Grab	43
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/16/2005	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	3/16/2005	Grab	<10
550/17.7	No Cr. Nr. Dunlap	3/17/2005	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	3/17/2005	Grab	<10
593/36.0	Grand R. @ Sumner	4/4/2005	Grab	55
550/17.7	No Cr. Nr. Dunlap	4/5/2005	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	4/7/2005	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/8/2005	Grab	79
623/14.2	L. Medicine Cr. @Hwy E	4/8/2005	Grab	18
593/36.0	Grand R. @ Sumner	5/3/2005	Grab	117
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/11/2005	Grab	15
674/28.8	Mussel Fk. nr. Mystic	5/11/2005	Grab	10
550/17.7	No Cr. Nr. Dunlap	5/12/2005	Grab	52
623/14.2	L. Medicine Cr. @Hwy E	5/12/2005	Grab	38
560/29.0	Weldon R. nr. Princeton	5/23/2005	Grab	277
549/49.6	Thompson R. at Mt. Moriah	5/25/2005	Grab	292
593/36.0	Grand R. @ Sumner	6/22/2005	Grab	203
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/29/2005	Grab	620
674/28.8	Mussel Fk. nr. Mystic	6/29/2005	Grab	21
550/17.7	No Cr. Nr. Dunlap	6/30/2005	Grab	24
623/14.2	L. Medicine Cr. @Hwy E	6/30/2005	Grab	20
560/29.0	Weldon R. nr. Princeton	7/6/2005	Grab	<10

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	7/8/2005	Grab	67
593/36.0	Grand R. @ Sumner	7/12/2005	Grab	127
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/12/2005	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	7/12/2005	Grab	<10
550/17.7	No Cr. Nr. Dunlap	7/13/2005	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	7/14/2005	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/17/2005	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	8/17/2005	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	8/18/2005	Grab	22
550/17.7	No Cr. Nr. Dunlap	8/19/2005	Grab	33
593/36.0	Grand R. @ Sumner	8/22/2005	Grab	252
593/36.0	Grand R. @ Sumner	9/7/2005	Grab	55
560/29.0	Weldon R. nr. Princeton	9/14/2005	Grab	10
549/49.6	Thompson R. at Mt. Moriah	9/16/2005	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/20/2005	Grab	14
623/14.2	L. Medicine Cr. @Hwy E	9/20/2005	Grab	<10
550/17.7	No Cr. Nr. Dunlap	9/21/2005	Grab	53
674/28.8	Mussel Fk. nr. Mystic	9/21/2005	Grab	37
674/28.8	Mussel Fk. nr. Mystic	10/4/2005	Grab	316
550/17.7	No Cr. Nr. Dunlap	10/5/2005	Grab	380
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/5/2005	Grab	11
623/14.2	L. Medicine Cr. @Hwy E	10/5/2005	Grab	<10
593/36.0	Grand R. @ Sumner	10/12/2005	Grab	34
674/28.8	Mussel Fk. nr. Mystic	11/1/2005	Grab	22
593/36.0	Grand R. @ Sumner	11/2/2005	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/2/2005	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/2/2005	Grab	<10
550/17.7	No Cr. Nr. Dunlap	11/3/2005	Grab	1510
560/29.0	Weldon R. nr. Princeton	11/8/2005	Grab	21
549/49.6	Thompson R. at Mt. Moriah	11/10/2005	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	12/13/2005	Grab	<10
550/17.7	No Cr. Nr. Dunlap	12/14/2005	Grab	44
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/15/2005	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	12/15/2005	Grab	<10
593/36.0	Grand R. @ Sumner	12/19/2005	Grab	<10
593/36.0	Grand R. @ Sumner	1/4/2006	Grab	14
560/29.0	Weldon R. nr. Princeton	1/18/2006	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	1/20/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	1/25/2006	Grab	43
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/26/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/26/2006	Grab	<10

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	1/27/2006	Grab	<10
593/36.0	Grand R. @ Sumner	2/7/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	2/14/2006	Grab	22
674/28.8	Mussel Fk. nr. Mystic	2/15/2006	Grab	15
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/17/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	2/17/2006	Grab	<10
593/36.0	Grand R. @ Sumner	3/7/2006	Grab	12
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/8/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	3/8/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	3/9/2006	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	3/9/2006	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	3/31/2006	Grab	<10
560/29.0	Weldon R. nr. Princeton	3/31/2006	Grab	750
593/36.0	Grand R. @ Sumner	4/10/2006	Grab	415
550/17.7	No Cr. Nr. Dunlap	4/12/2006	Grab	72
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/13/2006	Grab	15
623/14.2	L. Medicine Cr. @Hwy E	4/13/2006	Grab	15
674/28.8	Mussel Fk. nr. Mystic	4/14/2006	Grab	18
593/36.0	Grand R. @ Sumner	5/3/2006	Grab	1180
550/17.7	No Cr. Nr. Dunlap	5/9/2006	Grab	44
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/10/2006	Grab	20
623/14.2	L. Medicine Cr. @Hwy E	5/10/2006	Grab	19
674/28.8	Mussel Fk. nr. Mystic	5/12/2006	Grab	10
560/29.0	Weldon R. nr. Princeton	5/23/2006	Grab	12
549/49.6	Thompson R. at Mt. Moriah	5/25/2006	Grab	100
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/14/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	6/14/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	6/15/2006	Grab	24
674/28.8	Mussel Fk. nr. Mystic	6/15/2006	Grab	<10
593/36.0	Grand R. @ Sumner	6/21/2006	Grab	154
593/36.0	Grand R. @ Sumner	7/6/2006	Grab	41
674/28.8	Mussel Fk. nr. Mystic	7/17/2006	Grab	34
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/18/2006	Grab	16
550/17.7	No Cr. Nr. Dunlap	7/19/2006	Grab	152
623/14.2	L. Medicine Cr. @Hwy E	7/19/2006	Grab	<10
560/29.0	Weldon R. nr. Princeton	7/25/2006	Grab	60
549/49.6	Thompson R. at Mt. Moriah	7/27/2006	Grab	23
593/36.0	Grand R. @ Sumner	8/2/2006	Grab	138
674/28.8	Mussel Fk. nr. Mystic	8/8/2006	Grab	203
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/9/2006	Grab	150
623/14.2	L. Medicine Cr. @Hwy E	8/9/2006	Grab	122

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
550/17.7	No Cr. Nr. Dunlap	8/10/2006	Grab	147
560/29.0	Weldon R. nr. Princeton	9/6/2006	Grab	42
593/36.0	Grand R. @ Sumner	9/6/2006	Grab	167
549/49.6	Thompson R. at Mt. Moriah	9/8/2006	Grab	28
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/20/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	9/20/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	9/21/2006	Grab	170
674/28.8	Mussel Fk. nr. Mystic	9/21/2006	Grab	11
593/36.0	Grand R. @ Sumner	10/10/2006	Grab	51
674/28.8	Mussel Fk. nr. Mystic	10/23/2006	Grab	20
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/24/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	10/24/2006	Grab	<10
550/17.7	No Cr. Nr. Dunlap	10/25/2006	Grab	93
593/36.0	Grand R. @ Sumner	11/6/2006	Grab	43
560/29.0	Weldon R. nr. Princeton	11/7/2006	FieldDupl	<10
560/29.0	Weldon R. nr. Princeton	11/7/2006	FieldDupl	<10
549/49.6	Thompson R. at Mt. Moriah	11/9/2006	Grab	<10
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/15/2006	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	11/15/2006	Grab	82
550/17.7	No Cr. Nr. Dunlap	11/16/2006	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	11/16/2006	Grab	<10
593/36.0	Grand R. @ Sumner	12/5/2006	Grab	76
550/17.7	No Cr. Nr. Dunlap	12/13/2006	Grab	17
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/14/2006	Grab	24
623/14.2	L. Medicine Cr. @Hwy E	12/14/2006	Grab	13
674/28.8	Mussel Fk. nr. Mystic	12/15/2006	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	1/4/2007	Grab	333
560/29.0	Weldon R. nr. Princeton	1/4/2007	Grab	44
593/36.0	Grand R. @ Sumner	1/4/2007	Grab	767
674/28.8	Mussel Fk. nr. Mystic	1/24/2007	Grab	11
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/25/2007	Grab	<10
623/14.2	L. Medicine Cr. @Hwy E	1/25/2007	Grab	<10
550/17.7	No Cr. Nr. Dunlap	1/26/2007	Grab	<10
549/49.6	Thompson R. at Mt. Moriah	2/14/2007	Grab	<10
593/36.0	Grand R. @ Sumner	2/14/2007	FieldDupl	<10
593/36.0	Grand R. @ Sumner	2/14/2007	FieldDupl	<10
560/29.0	Weldon R. nr. Princeton	2/16/2007	Grab	<10
550/17.7	No Cr. Nr. Dunlap	2/20/2007	Grab	162
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/21/2007	Grab	379
623/14.2	L. Medicine Cr. @Hwy E	2/21/2007	Grab	59
674/28.8	Mussel Fk. nr. Mystic	2/22/2007	Grab	<10

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	3/7/2007	Grab	258
674/28.8	Mussel Fk. nr. Mystic	3/13/2007	Grab	25
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/14/2007	Grab	72
550/17.7	No Cr. Nr. Dunlap	3/15/2007	Grab	37
623/14.2	L. Medicine Cr. @Hwy E	3/15/2007	Grab	64
549/49.6	Thompson R. at Mt. Moriah	3/21/2007	Grab	218
560/29.0	Weldon R. nr. Princeton	3/23/2007	Grab	1250
593/36.0	Grand R. @ Sumner	4/3/2007	Grab	1120
549/49.6	Thompson R. at Mt. Moriah	4/6/2007	Grab	192
560/29.0	Weldon R. nr. Princeton	4/6/2007	Grab	86
674/28.8	Mussel Fk. nr. Mystic	4/24/2007	Grab	<50
623/14.2	L. Medicine Cr. @Hwy E	4/25/2007	Grab	1070
550/17.7	No Cr. Nr. Dunlap	4/27/2007	Grab	225
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/27/2007	Grab	660
593/36.0	Grand R. @ Sumner	5/2/2007	Grab	360
674/28.8	Mussel Fk. nr. Mystic	5/8/2007	Grab	176
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/9/2007	Grab	424
550/17.7	No Cr. Nr. Dunlap	5/10/2007	Grab	110
623/14.2	L. Medicine Cr. @Hwy E	5/10/2007	Grab	184
549/49.6	Thompson R. at Mt. Moriah	5/23/2007	Grab	63
560/29.0	Weldon R. nr. Princeton	5/23/2007	Grab	28
593/36.0	Grand R. @ Sumner	6/6/2007	Grab	200
549/49.6	Thompson R. at Mt. Moriah	6/20/2007	Grab	82
560/29.0	Weldon R. nr. Princeton	6/20/2007	Grab	31
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/27/2007	Grab	19
623/14.2	L. Medicine Cr. @Hwy E	6/27/2007	Grab	10
550/17.7	No Cr. Nr. Dunlap	6/28/2007	Grab	485
674/28.8	Mussel Fk. nr. Mystic	6/28/2007	Grab	444
593/36.0	Grand R. @ Sumner	7/10/2007	Grab	104
674/28.8	Mussel Fk. nr. Mystic	7/17/2007	Grab	26
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/18/2007	Grab	10
623/14.2	L. Medicine Cr. @Hwy E	7/18/2007	Grab	13
550/17.7	No Cr. Nr. Dunlap	7/19/2007	Grab	165
549/49.6	Thompson R. at Mt. Moriah	7/25/2007	Grab	17
560/29.0	Weldon R. nr. Princeton	7/25/2007	Grab	15
593/36.0	Grand R. @ Sumner	8/14/2007	Grab	242
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/21/2007	Grab	763
623/14.2	L. Medicine Cr. @Hwy E	8/21/2007	Grab	663
674/28.8	Mussel Fk. nr. Mystic	8/22/2007	Grab	245
550/17.7	No Cr. Nr. Dunlap	8/23/2007	Grab	75
593/36.0	Grand R. @ Sumner	9/11/2007	Grab	52

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
550/17.7	No Cr. Nr. Dunlap	9/16/2007	Grab	136
549/49.6	Thompson R. at Mt. Moriah	9/19/2007	Grab	26
560/29.0	Weldon R. nr. Princeton	9/19/2007	Grab	24
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/25/2007	Grab	<20
623/14.2	L. Medicine Cr. @Hwy E	9/25/2007	Grab	<20
674/28.8	Mussel Fk. nr. Mystic	9/26/2007	Grab	54
550/17.7	No Cr. Nr. Dunlap	9/27/2007	Grab	105
550/17.7	No Cr. Nr. Dunlap	10/8/2007	Grab	16
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/16/2007	Grab	84
623/14.2	L. Medicine Cr. @Hwy E	10/17/2007	Grab	424
674/28.8	Mussel Fk. nr. Mystic	10/17/2007	Grab	312
593/36.0	Grand R. @ Sumner	10/23/2007	Grab	340
593/36.0	Grand R. @ Sumner	11/6/2007	Grab	27
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/6/2007	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	11/7/2007	Grab	11
623/14.2	L. Medicine Cr. @Hwy E	11/8/2007	Grab	<10
560/29.0	Weldon R. nr. Princeton	11/14/2007	FieldDupl	13
560/29.0	Weldon R. nr. Princeton	11/14/2007	FieldDupl	<10
549/49.6	Thompson R. at Mt. Moriah	11/16/2007	Grab	48
593/36.0	Grand R. @ Sumner	12/4/2007	Grab	45
674/28.8	Mussel Fk. nr. Mystic	12/18/2007	Grab	20
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/19/2007	Grab	35
623/14.2	L. Medicine Cr. @Hwy E	12/19/2007	Grab	31
550/17.7	No Cr. Nr. Dunlap	12/20/2007	Grab	20
593/36.0	Grand R. @ Sumner	1/9/2008	Grab	850
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/9/2008	Grab	406
674/28.8	Mussel Fk. nr. Mystic	1/9/2008	Grab	68
550/17.7	No Cr. Nr. Dunlap	1/10/2008	Grab	58
623/14.2	L. Medicine Cr. @Hwy E	1/10/2008	Grab	88
549/49.6	Thompson R. at Mt. Moriah	1/24/2008	Grab	20
560/29.0	Weldon R. nr. Princeton	1/24/2008	Grab	140
593/36.0	Grand R. @ Sumner	2/14/2008	Grab	100
550/17.7	No Cr. Nr. Dunlap	2/26/2008	Grab	86
674/28.8	Mussel Fk. nr. Mystic	2/26/2008	Grab	180
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/27/2008	Grab	140
623/14.2	L. Medicine Cr. @Hwy E	2/27/2008	Grab	82
593/36.0	Grand R. @ Sumner	3/5/2008	Grab	1180
549/49.6	Thompson R. at Mt. Moriah	3/12/2008	Grab	328
560/29.0	Weldon R. nr. Princeton	3/12/2008	Grab	472
550/17.7	No Cr. Nr. Dunlap	3/25/2008	Grab	34
674/28.8	Mussel Fk. nr. Mystic	3/25/2008	Grab	21

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/26/2008	Grab	49
623/14.2	L. Medicine Cr. @Hwy E	3/26/2008	Grab	43
550/17.7	No Cr. Nr. Dunlap	4/16/2008	Grab	102
593/36.0	Grand R. @ Sumner	4/16/2008	Grab	144
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/16/2008	Grab	170
623/14.2	L. Medicine Cr. @Hwy E	4/16/2008	Grab	88
674/28.8	Mussel Fk. nr. Mystic	4/17/2008	Grab	28
593/36.0	Grand R. @ Sumner	5/6/2008	Grab	222
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/21/2008	Grab	19
623/14.2	L. Medicine Cr. @Hwy E	5/21/2008	Grab	<10
550/17.7	No Cr. Nr. Dunlap	5/22/2008	Grab	138
674/28.8	Mussel Fk. nr. Mystic	5/22/2008	Grab	10
549/49.6	Thompson R. at Mt. Moriah	5/29/2008	Grab	196
560/29.0	Weldon R. nr. Princeton	5/29/2008	Grab	79
593/36.0	Grand R. @ Sumner	6/2/2008	Grab	1120
550/17.7	No Cr. Nr. Dunlap	6/17/2008	Grab	74
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/18/2008	Grab	148
623/14.2	L. Medicine Cr. @Hwy E	6/18/2008	Grab	74
674/28.8	Mussel Fk. nr. Mystic	6/19/2008	Grab	25
593/36.0	Grand R. @ Sumner	7/9/2008	Grab	384
549/49.6	Thompson R. at Mt. Moriah	7/10/2008	Grab	1440
560/29.0	Weldon R. nr. Princeton	7/10/2008	Grab	426
550/17.7	No Cr. Nr. Dunlap	7/15/2008	Grab	46
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/16/2008	Grab	35
623/14.2	L. Medicine Cr. @Hwy E	7/16/2008	Grab	10
674/28.8	Mussel Fk. nr. Mystic	7/18/2008	Grab	16
593/36.0	Grand R. @ Sumner	8/4/2008	Grab	452
550/17.7	No Cr. Nr. Dunlap	8/12/2008	Grab	24
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/13/2008	Grab	46
623/14.2	L. Medicine Cr. @Hwy E	8/13/2008	Grab	13
674/28.8	Mussel Fk. nr. Mystic	8/14/2008	Grab	182
593/36.0	Grand R. @ Sumner	9/2/2008	Grab	80
549/49.6	Thompson R. at Mt. Moriah	9/17/2008	Grab	300
560/29.0	Weldon R. nr. Princeton	9/17/2008	Grab	364
550/17.7	No Cr. Nr. Dunlap	9/23/2008	Grab	<10
674/28.8	Mussel Fk. nr. Mystic	9/23/2008	Grab	14
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/24/2008	Grab	536
623/14.2	L. Medicine Cr. @Hwy E	9/24/2008	Grab	2200
593/36.0	Grand R. @ Sumner	1/13/2009	Grab	59
549/49.6	Thompson R. at Mt. Moriah	1/14/2009	Grab	74
560/29.0	Weldon R. nr. Princeton	1/14/2009	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
550/17.7	No Cr. Nr. Dunlap	1/27/2009	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/28/2009	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/28/2009	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	1/29/2009	Grab	<15
593/36.0	Grand R. @ Sumner	2/2/2009	Grab	<15
550/17.7	No Cr. Nr. Dunlap	2/24/2009	Grab	16
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/25/2009	Grab	22
623/14.2	L. Medicine Cr. @Hwy E	2/25/2009	Grab	18
674/28.8	Mussel Fk. nr. Mystic	2/26/2009	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	3/5/2009	Grab	254
560/29.0	Weldon R. nr. Princeton	3/6/2009	Grab	112
593/36.0	Grand R. @ Sumner	3/10/2009	Grab	1300
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/11/2009	Grab	1180
623/14.2	L. Medicine Cr. @Hwy E	3/11/2009	Grab	490
550/17.7	No Cr. Nr. Dunlap	3/12/2009	Grab	250
674/28.8	Mussel Fk. nr. Mystic	3/12/2009	Grab	170
593/36.0	Grand R. @ Sumner	4/1/2009	Grab	418
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/22/2009	Grab	85
623/14.2	L. Medicine Cr. @Hwy E	4/22/2009	Grab	15
674/28.8	Mussel Fk. nr. Mystic	4/23/2009	Grab	<15
550/17.7	No Cr. Nr. Dunlap	4/24/2009	Grab	16
593/36.0	Grand R. @ Sumner	5/5/2009	Grab	780
549/49.6	Thompson R. at Mt. Moriah	5/7/2009	Grab	336
560/29.0	Weldon R. nr. Princeton	5/7/2009	Grab	126
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/13/2009	Grab	1900
623/14.2	L. Medicine Cr. @Hwy E	5/13/2009	Grab	1760
674/28.8	Mussel Fk. nr. Mystic	5/14/2009	Grab	214
550/17.7	No Cr. Nr. Dunlap	5/15/2009	Grab	730
593/36.0	Grand R. @ Sumner	6/2/2009	Grab	312
550/17.7	No Cr. Nr. Dunlap	6/23/2009	Grab	<150
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/24/2009	Grab	220
623/14.2	L. Medicine Cr. @Hwy E	6/24/2009	Grab	160
674/28.8	Mussel Fk. nr. Mystic	6/26/2009	Grab	<150
549/49.6	Thompson R. at Mt. Moriah	7/16/2009	Grab	718
560/29.0	Weldon R. nr. Princeton	7/16/2009	Grab	54
674/28.8	Mussel Fk. nr. Mystic	7/21/2009	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/22/2009	Grab	24
623/14.2	L. Medicine Cr. @Hwy E	7/22/2009	Grab	<15
550/17.7	No Cr. Nr. Dunlap	7/24/2009	Grab	23
593/36.0	Grand R. @ Sumner	7/28/2009	Grab	62
593/36.0	Grand R. @ Sumner	8/17/2009	Grab	1790

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
550/17.7	No Cr. Nr. Dunlap	8/18/2009	Grab	266
674/28.8	Mussel Fk. nr. Mystic	8/19/2009	Grab	106
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/20/2009	Grab	455
623/14.2	L. Medicine Cr. @Hwy E	8/20/2009	Grab	1290
593/36.0	Grand R. @ Sumner	9/1/2009	Grab	454
549/49.6	Thompson R. at Mt. Moriah	9/3/2009	Grab	109
560/29.0	Weldon R. nr. Princeton	9/3/2009	Grab	145
550/17.7	No Cr. Nr. Dunlap	9/15/2009	Grab	83
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/16/2009	Grab	22
623/14.2	L. Medicine Cr. @Hwy E	9/16/2009	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	9/17/2009	Grab	33
550/17.7	No Cr. Nr. Dunlap	10/6/2009	Grab	99
674/28.8	Mussel Fk. nr. Mystic	10/7/2009	Grab	51
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/8/2009	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	10/8/2009	Grab	26
593/36.0	Grand R. @ Sumner	10/15/2009	Grab	25
549/49.6	Thompson R. at Mt. Moriah	10/21/2009	Grab	137
560/29.0	Weldon R. nr. Princeton	10/21/2009	Grab	<15
550/17.7	No Cr. Nr. Dunlap	11/3/2009	Grab	26
593/36.0	Grand R. @ Sumner	11/3/2009	Grab	537
674/28.8	Mussel Fk. nr. Mystic	11/4/2009	Grab	19
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/5/2009	Grab	71
623/14.2	L. Medicine Cr. @Hwy E	11/5/2009	Grab	31
550/17.7	No Cr. Nr. Dunlap	12/1/2009	Grab	<15
593/36.0	Grand R. @ Sumner	12/1/2009	Grab	189
674/28.8	Mussel Fk. nr. Mystic	12/2/2009	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/3/2009	Grab	37
623/14.2	L. Medicine Cr. @Hwy E	12/3/2009	Grab	<15
593/36.0	Grand R. @ Sumner	1/13/2010	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	1/14/2010	Grab	36
560/29.0	Weldon R. nr. Princeton	1/14/2010	Grab	23
674/28.8	Mussel Fk. nr. Mystic	1/26/2010	Grab	98
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/27/2010	Grab	91
623/14.2	L. Medicine Cr. @Hwy E	1/27/2010	Grab	103
550/17.7	No Cr. Nr. Dunlap	1/28/2010	Grab	54
593/36.0	Grand R. @ Sumner	2/2/2010	Grab	96
550/17.7	No Cr. Nr. Dunlap	2/23/2010	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/24/2010	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	2/24/2010	Grab	20
674/28.8	Mussel Fk. nr. Mystic	2/25/2010	Grab	<15
593/36.0	Grand R. @ Sumner	3/2/2010	Grab	73

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	3/3/2010	Grab	72
560/29.0	Weldon R. nr. Princeton	3/3/2010	Grab	52
674/28.8	Mussel Fk. nr. Mystic	3/17/2010	Grab	86
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/18/2010	Grab	686
623/14.2	L. Medicine Cr. @Hwy E	3/18/2010	Grab	388
550/17.7	No Cr. Nr. Dunlap	3/19/2010	Grab	108
593/36.0	Grand R. @ Sumner	4/14/2010	Grab	105
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/21/2010	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	4/21/2010	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	4/22/2010	Grab	<15
550/17.7	No Cr. Nr. Dunlap	4/23/2010	Grab	67
549/49.6	Thompson R. at Mt. Moriah	5/6/2010	Grab	192
560/29.0	Weldon R. nr. Princeton	5/6/2010	Grab	102
550/17.7	No Cr. Nr. Dunlap	5/18/2010	Grab	322
674/28.8	Mussel Fk. nr. Mystic	5/19/2010	Grab	84
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/20/2010	Grab	220
623/14.2	L. Medicine Cr. @Hwy E	5/20/2010	Grab	730
593/36.0	Grand R. @ Sumner	5/26/2010	Grab	1840
550/17.7	No Cr. Nr. Dunlap	6/15/2010	Grab	822
593/36.0	Grand R. @ Sumner	6/15/2010	Grab	1600
674/28.8	Mussel Fk. nr. Mystic	6/16/2010	Grab	152
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/17/2010	Grab	758
623/14.2	L. Medicine Cr. @Hwy E	6/17/2010	Grab	200
593/36.0	Grand R. @ Sumner	7/6/2010	Grab	2660
549/49.6	Thompson R. at Mt. Moriah	7/15/2010	Grab	198
560/29.0	Weldon R. nr. Princeton	7/15/2010	Grab	70
550/17.7	No Cr. Nr. Dunlap	7/27/2010	Grab	<29
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/28/2010	Grab	65
623/14.2	L. Medicine Cr. @Hwy E	7/28/2010	Grab	<28
674/28.8	Mussel Fk. nr. Mystic	7/29/2010	Grab	35
593/36.0	Grand R. @ Sumner	8/3/2010	Grab	184
550/17.7	No Cr. Nr. Dunlap	8/17/2010	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	8/18/2010	Grab	25
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/19/2010	Grab	23
623/14.2	L. Medicine Cr. @Hwy E	8/19/2010	Grab	<15
593/36.0	Grand R. @ Sumner	9/14/2010	Grab	772
549/49.6	Thompson R. at Mt. Moriah	9/15/2010	Grab	119
560/29.0	Weldon R. nr. Princeton	9/15/2010	Grab	654
550/17.7	No Cr. Nr. Dunlap	9/21/2010	Grab	210
623/14.2	L. Medicine Cr. @Hwy E	9/22/2010	Grab	2260
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/23/2010	Grab	1650

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	9/23/2010	Grab	164
550/17.7	No Cr. Nr. Dunlap	10/5/2010	Grab	<15
593/36.0	Grand R. @ Sumner	10/5/2010	Grab	122
674/28.8	Mussel Fk. nr. Mystic	10/6/2010	Grab	23
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/7/2010	Grab	19
623/14.2	L. Medicine Cr. @Hwy E	10/7/2010	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	10/21/2010	Grab	25
560/29.0	Weldon R. nr. Princeton	10/21/2010	Grab	<15
550/17.7	No Cr. Nr. Dunlap	11/2/2010	Grab	<15
593/36.0	Grand R. @ Sumner	11/3/2010	Grab	194
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/3/2010	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/3/2010	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	11/4/2010	Grab	<15
593/36.0	Grand R. @ Sumner	12/1/2010	Grab	15
593/36.0	Grand R. @ Sumner	12/1/2010	Grab	18
550/17.7	No Cr. Nr. Dunlap	1/4/2011	Grab	<15
593/36.0	Grand R. @ Sumner	1/5/2011	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/5/2011	Grab	23
623/14.2	L. Medicine Cr. @Hwy E	1/5/2011	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	1/6/2011	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	1/12/2011	Grab	<15
560/29.0	Weldon R. nr. Princeton	1/12/2011	Grab	<15
593/36.0	Grand R. @ Sumner	2/8/2011	Grab	<15
606/20.6	Locust Cr. @ Calico Rd.	2/15/2011	Grab	14
674/28.8	Mussel Fk. nr. Mystic	2/16/2011	Grab	160
550/17.7	No Cr. Nr. Dunlap	2/17/2011	Grab	1480
623/14.2	L. Medicine Cr. @Hwy E	2/17/2011	Grab	1520
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/18/2011	Grab	2100
593/36.0	Grand R. @ Sumner	3/8/2011	Grab	182
606/20.6	Locust Cr. @ Calico Rd.	3/15/2011	Grab	56
549/49.6	Thompson R. at Mt. Moriah	3/16/2011	Grab	198
560/29.0	Weldon R. nr. Princeton	3/16/2011	Grab	104
674/28.8	Mussel Fk. nr. Mystic	3/23/2011	Grab	632
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/24/2011	Grab	460
623/14.2	L. Medicine Cr. @Hwy E	3/24/2011	Grab	272
550/17.7	No Cr. Nr. Dunlap	3/25/2011	Grab	15
550/17.7	No Cr. Nr. Dunlap	4/5/2011	Grab	21
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/6/2011	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	4/6/2011	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	4/7/2011	Grab	<15
593/36.0	Grand R. @ Sumner	4/19/2011	Grab	1070

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
606/20.6	Locust Cr. @ Calico Rd.	4/19/2011	Grab	206
550/17.7	No Cr. Nr. Dunlap	5/3/2011	Grab	24
593/36.0	Grand R. @ Sumner	5/3/2011	Grab	226
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/4/2011	Grab	29
623/14.2	L. Medicine Cr. @Hwy E	5/4/2011	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	5/5/2011	Grab	44
606/20.6	Locust Cr. @ Calico Rd.	5/17/2011	Grab	126
549/49.6	Thompson R. at Mt. Moriah	5/25/2011	Grab	1560
560/29.0	Weldon R. nr. Princeton	5/25/2011	Grab	1280
606/20.6	Locust Cr. @ Calico Rd.	5/26/2011	Grab	3420
550/17.7	No Cr. Nr. Dunlap	6/7/2011	Grab	24
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/8/2011	Grab	40
623/14.2	L. Medicine Cr. @Hwy E	6/8/2011	Grab	18
674/28.8	Mussel Fk. nr. Mystic	6/9/2011	Grab	37
593/36.0	Grand R. @ Sumner	6/14/2011	Grab	380
606/20.6	Locust Cr. @ Calico Rd.	6/16/2011	Grab	95
550/17.7	No Cr. Nr. Dunlap	7/12/2011	Grab	<15
593/36.0	Grand R. @ Sumner	7/12/2011	Grab	62
606/20.6	Locust Cr. @ Calico Rd.	7/13/2011	Grab	106
674/28.8	Mussel Fk. nr. Mystic	7/13/2011	Grab	1390
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/14/2011	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	7/14/2011	Grab	16
560/29.0	Weldon R. nr. Princeton	7/18/2011	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	7/19/2011	Grab	108
593/36.0	Grand R. @ Sumner	8/3/2011	Grab	74
550/17.7	No Cr. Nr. Dunlap	8/16/2011	Grab	1280
674/28.8	Mussel Fk. nr. Mystic	8/17/2011	Grab	47
606/20.6	Locust Cr. @ Calico Rd.	8/18/2011	Grab	15
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/18/2011	Grab	36
623/14.2	L. Medicine Cr. @Hwy E	8/18/2011	Grab	74
593/36.0	Grand R. @ Sumner	9/7/2011	Grab	34
550/17.7	No Cr. Nr. Dunlap	9/13/2011	Grab	40
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/14/2011	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	9/14/2011	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	9/15/2011	Grab	20
606/20.6	Locust Cr. @ Calico Rd.	9/16/2011	Grab	21
549/49.6	Thompson R. at Mt. Moriah	9/28/2011	Grab	<15
560/29.0	Weldon R. nr. Princeton	9/28/2011	Grab	<15
550/17.7	No Cr. Nr. Dunlap	10/5/2011	Grab	35
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/6/2011	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	10/6/2011	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	10/13/2011	Grab	67
606/20.6	Locust Cr. @ Calico Rd.	10/18/2011	Grab	7
549/49.6	Thompson R. at Mt. Moriah	10/19/2011	Grab	<30
560/29.0	Weldon R. nr. Princeton	10/19/2011	Grab	<30
550/17.7	No Cr. Nr. Dunlap	11/1/2011	Grab	74
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/3/2011	Grab	28
623/14.2	L. Medicine Cr. @Hwy E	11/3/2011	Grab	52
593/36.0	Grand R. @ Sumner	11/8/2011	Grab	92
550/17.7	No Cr. Nr. Dunlap	1/10/2012	Grab	<15
593/36.0	Grand R. @ Sumner	1/11/2012	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/12/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/12/2012	Grab	<15
606/20.6	Locust Cr. @ Calico Rd.	1/19/2012	Grab	9
549/49.6	Thompson R. at Mt. Moriah	1/25/2012	Grab	<15
560/29.0	Weldon R. nr. Princeton	1/25/2012	Grab	<15
593/36.0	Grand R. @ Sumner	2/7/2012	Grab	153
550/17.7	No Cr. Nr. Dunlap	2/14/2012	Grab	23
606/20.6	Locust Cr. @ Calico Rd.	2/15/2012	Grab	12
674/28.8	Mussel Fk. nr. Mystic	2/15/2012	Grab	24
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/16/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	2/16/2012	Grab	22
550/17.7	No Cr. Nr. Dunlap	3/6/2012	Grab	36
593/36.0	Grand R. @ Sumner	3/7/2012	Grab	100
674/28.8	Mussel Fk. nr. Mystic	3/7/2012	Grab	33
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/8/2012	Grab	35
623/14.2	L. Medicine Cr. @Hwy E	3/8/2012	Grab	41
606/20.6	Locust Cr. @ Calico Rd.	3/20/2012	Grab	636
549/49.6	Thompson R. at Mt. Moriah	3/21/2012	Grab	6110
560/29.0	Weldon R. nr. Princeton	3/21/2012	Grab	1360
593/36.0	Grand R. @ Sumner	4/10/2012	Grab	254
550/17.7	No Cr. Nr. Dunlap	4/17/2012	Grab	57
674/28.8	Mussel Fk. nr. Mystic	4/18/2012	Grab	29
606/20.6	Locust Cr. @ Calico Rd.	4/19/2012	Grab	80
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/19/2012	Grab	106
623/14.2	L. Medicine Cr. @Hwy E	4/19/2012	Grab	71
549/49.6	Thompson R. at Mt. Moriah	5/2/2012	Grab	410
560/29.0	Weldon R. nr. Princeton	5/2/2012	Grab	314
593/36.0	Grand R. @ Sumner	5/3/2012	Grab	2580
606/20.6	Locust Cr. @ Calico Rd.	5/16/2012	Grab	12
550/17.7	No Cr. Nr. Dunlap	5/23/2012	Grab	16
674/28.8	Mussel Fk. nr. Mystic	5/23/2012	Grab	15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/24/2012	Grab	<15
550/17.7	No Cr. Nr. Dunlap	6/5/2012	Grab	<15
593/36.0	Grand R. @ Sumner	6/5/2012	Grab	57
674/28.8	Mussel Fk. nr. Mystic	6/6/2012	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/7/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	6/7/2012	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	7/19/2012	Grab	29
560/29.0	Weldon R. nr. Princeton	7/19/2012	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/25/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	7/25/2012	Grab	<15
593/36.0	Grand R. @ Sumner	8/6/2012	Grab	47
593/36.0	Grand R. @ Sumner	8/6/2012	Grab	50
549/49.6	Thompson R. at Mt. Moriah	8/7/2012	Grab	184
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/8/2012	Grab	37
623/14.2	L. Medicine Cr. @Hwy E	8/8/2012	Grab	<15
606/20.6	Locust Cr. @ Calico Rd.	8/22/2012	Grab	24
593/36.0	Grand R. @ Sumner	9/5/2012	Grab	86
549/49.6	Thompson R. at Mt. Moriah	9/10/2012	Grab	376
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/11/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	9/11/2012	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	9/20/2012	Grab	<15
560/29.0	Weldon R. nr. Princeton	9/20/2012	Grab	18
549/49.6	Thompson R. at Mt. Moriah	10/2/2012	Grab	<15
593/36.0	Grand R. @ Sumner	10/3/2012	Grab	54
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/3/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	10/3/2012	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	10/17/2012	Grab	<15
560/29.0	Weldon R. nr. Princeton	10/17/2012	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/6/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/6/2012	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	11/7/2012	Grab	<15
550/17.7	No Cr. Nr. Dunlap	12/3/2012	Grab	23
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/4/2012	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	12/4/2012	Grab	<15
593/36.0	Grand R. @ Sumner	12/5/2012	Grab	45
593/36.0	Grand R. @ Sumner	1/9/2013	Grab	20
550/17.7	No Cr. Nr. Dunlap	1/14/2013	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/15/2013	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/15/2013	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	1/16/2013	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	1/30/2013	Grab	300

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
560/29.0	Weldon R. nr. Princeton	1/30/2013	Grab	253
593/36.0	Grand R. @ Sumner	2/6/2013	Grab	27
550/17.7	No Cr. Nr. Dunlap	2/11/2013	Grab	64
674/28.8	Mussel Fk. nr. Mystic	2/12/2013	Grab	60
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/13/2013	Grab	31
623/14.2	L. Medicine Cr. @Hwy E	2/13/2013	Grab	<15
593/36.0	Grand R. @ Sumner	3/5/2013	Grab	26
549/49.6	Thompson R. at Mt. Moriah	3/6/2013	Grab	15
560/29.0	Weldon R. nr. Princeton	3/6/2013	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	3/12/2013	Grab	98
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/13/2013	Grab	215
623/14.2	L. Medicine Cr. @Hwy E	3/13/2013	Grab	153
550/17.7	No Cr. Nr. Dunlap	3/14/2013	Grab	90
593/36.0	Grand R. @ Sumner	4/1/2013	Grab	265
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/9/2013	Grab	72
623/14.2	L. Medicine Cr. @Hwy E	4/9/2013	Grab	69
674/28.8	Mussel Fk. nr. Mystic	4/10/2013	Grab	1450
550/17.7	No Cr. Nr. Dunlap	4/11/2013	Grab	910
593/36.0	Grand R. @ Sumner	5/8/2013	Grab	445
549/49.6	Thompson R. at Mt. Moriah	5/9/2013	Grab	278
560/29.0	Weldon R. nr. Princeton	5/9/2013	Grab	206
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/21/2013	Grab	156
623/14.2	L. Medicine Cr. @Hwy E	5/21/2013	Grab	188
674/28.8	Mussel Fk. nr. Mystic	5/22/2013	Grab	31
550/17.7	No Cr. Nr. Dunlap	5/23/2013	Grab	<15
593/36.0	Grand R. @ Sumner	6/19/2013	Grab	440
550/17.7	No Cr. Nr. Dunlap	6/24/2013	Grab	92
674/28.8	Mussel Fk. nr. Mystic	6/25/2013	Grab	70
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/26/2013	Grab	298
623/14.2	L. Medicine Cr. @Hwy E	6/26/2013	Grab	15
550/17.7	No Cr. Nr. Dunlap	7/8/2013	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	7/9/2013	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/10/2013	Grab	18
623/14.2	L. Medicine Cr. @Hwy E	7/10/2013	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	7/17/2013	Grab	230
560/29.0	Weldon R. nr. Princeton	7/17/2013	Grab	21
593/36.0	Grand R. @ Sumner	7/31/2013	Grab	75
550/17.7	No Cr. Nr. Dunlap	8/12/2013	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	8/13/2013	Grab	82
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/14/2013	Grab	248
623/14.2	L. Medicine Cr. @Hwy E	8/14/2013	Grab	15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	8/21/2013	Grab	46
593/36.0	Grand R. @ Sumner	9/12/2013	Grab	40
550/17.7	No Cr. Nr. Dunlap	9/17/2013	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/18/2013	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	9/18/2013	Grab	<15
606/20.6	Locust Cr. @ Calico Rd.	9/19/2013	Grab	<15
560/29.0	Weldon R. nr. Princeton	9/24/2013	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	9/25/2013	Grab	345
549/49.6	Thompson R. at Mt. Moriah	10/23/2013	Grab	<15
560/29.0	Weldon R. nr. Princeton	10/23/2013	Grab	<15
593/36.0	Grand R. @ Sumner	10/30/2013	Grab	38
550/17.7	No Cr. Nr. Dunlap	11/4/2013	Grab	<30
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/5/2013	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/5/2013	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	11/6/2013	Grab	<60
593/36.0	Grand R. @ Sumner	11/25/2013	Grab	<30
593/36.0	Grand R. @ Sumner	12/10/2013	Grab	76
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/11/2013	Grab	<30
623/14.2	L. Medicine Cr. @Hwy E	12/11/2013	Grab	<30
549/49.6	Thompson R. at Mt. Moriah	12/12/2013	Grab	<30
549/49.6	Thompson R. at Mt. Moriah	1/13/2014	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/15/2014	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/15/2014	Grab	<15
593/36.0	Grand R. @ Sumner	1/28/2014	Grab	<30
549/49.6	Thompson R. at Mt. Moriah	1/29/2014	Grab	<15
560/29.0	Weldon R. nr. Princeton	1/29/2014	Grab	21
593/36.0	Grand R. @ Sumner	2/19/2014	Grab	<30
550/17.7	No Cr. Nr. Dunlap	2/24/2014	Grab	74
674/28.8	Mussel Fk. nr. Mystic	2/25/2014	Grab	<21
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/26/2014	Grab	<21
623/14.2	L. Medicine Cr. @Hwy E	2/26/2014	Grab	16
674/28.8	Mussel Fk. nr. Mystic	3/10/2014	Grab	22
550/17.7	No Cr. Nr. Dunlap	3/11/2014	Grab	42
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/12/2014	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	3/12/2014	Grab	76
549/49.6	Thompson R. at Mt. Moriah	3/19/2014	Grab	60
560/29.0	Weldon R. nr. Princeton	3/19/2014	Grab	76
593/36.0	Grand R. @ Sumner	3/24/2014	Grab	<30
550/17.7	No Cr. Nr. Dunlap	4/7/2014	Grab	<15
593/36.0	Grand R. @ Sumner	4/8/2014	Grab	57
674/28.8	Mussel Fk. nr. Mystic	4/8/2014	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/9/2014	Grab	<21
623/14.2	L. Medicine Cr. @Hwy E	4/9/2014	Grab	<21
550/17.7	No Cr. Nr. Dunlap	5/5/2014	Grab	26
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/6/2014	Grab	40
623/14.2	L. Medicine Cr. @Hwy E	5/6/2014	Grab	<21
674/28.8	Mussel Fk. nr. Mystic	5/7/2014	Grab	70
549/49.6	Thompson R. at Mt. Moriah	5/20/2014	Grab	266
560/29.0	Weldon R. nr. Princeton	5/20/2014	Grab	61
593/36.0	Grand R. @ Sumner	5/28/2014	Grab	264
550/17.7	No Cr. Nr. Dunlap	6/9/2014	Grab	195
674/28.8	Mussel Fk. nr. Mystic	6/10/2014	Grab	72
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/11/2014	Grab	535
623/14.2	L. Medicine Cr. @Hwy E	6/11/2014	Grab	365
593/36.0	Grand R. @ Sumner	6/17/2014	Grab	260
549/49.6	Thompson R. at Mt. Moriah	7/9/2014	Grab	1280
560/29.0	Weldon R. nr. Princeton	7/9/2014	Grab	540
593/36.0	Grand R. @ Sumner	7/9/2014	Grab	1930
550/17.7	No Cr. Nr. Dunlap	7/15/2014	Grab	36
674/28.8	Mussel Fk. nr. Mystic	7/16/2014	Grab	23
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/17/2014	Grab	48
623/14.2	L. Medicine Cr. @Hwy E	7/17/2014	Grab	16
593/36.0	Grand R. @ Sumner	8/12/2014	Grab	125
550/17.7	No Cr. Nr. Dunlap	8/18/2014	Grab	20
674/28.8	Mussel Fk. nr. Mystic	8/19/2014	Grab	66
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/20/2014	Grab	70
623/14.2	L. Medicine Cr. @Hwy E	8/20/2014	Grab	17
549/49.6	Thompson R. at Mt. Moriah	9/4/2014	Grab	1040
560/29.0	Weldon R. nr. Princeton	9/4/2014	Grab	220
593/36.0	Grand R. @ Sumner	9/8/2014	Grab	399
550/17.7	No Cr. Nr. Dunlap	9/22/2014	Grab	28
674/28.8	Mussel Fk. nr. Mystic	9/23/2014	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/24/2014	Grab	22
623/14.2	L. Medicine Cr. @Hwy E	9/24/2014	Grab	<15
550/17.7	No Cr. Nr. Dunlap	10/6/2014	Grab	26
593/36.0	Grand R. @ Sumner	10/7/2014	Grab	464
674/28.8	Mussel Fk. nr. Mystic	10/7/2014	Grab	17
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/8/2014	Grab	59
623/14.2	L. Medicine Cr. @Hwy E	10/8/2014	Grab	19
549/49.6	Thompson R. at Mt. Moriah	10/22/2014	Grab	152
560/29.0	Weldon R. nr. Princeton	10/22/2014	Grab	57
550/17.7	No Cr. Nr. Dunlap	11/3/2014	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
593/36.0	Grand R. @ Sumner	11/4/2014	Grab	86
674/28.8	Mussel Fk. nr. Mystic	11/4/2014	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/5/2014	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/5/2014	Grab	<15
550/17.7	No Cr. Nr. Dunlap	12/8/2014	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	12/9/2014	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/10/2014	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	12/10/2014	Grab	<15
593/36.0	Grand R. @ Sumner	12/16/2014	Grab	34
549/49.6	Thompson R. at Mt. Moriah	1/7/2015	Grab	31
560/29.0	Weldon R. nr. Princeton	1/8/2015	Grab	<15
550/17.7	No Cr. Nr. Dunlap	1/12/2015	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	1/13/2015	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/14/2015	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/14/2015	Grab	<15
593/36.0	Grand R. @ Sumner	1/21/2015	Grab	<15
593/36.0	Grand R. @ Sumner	2/10/2015	Grab	596
674/28.8	Mussel Fk. nr. Mystic	2/17/2015	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/18/2015	Grab	15
623/14.2	L. Medicine Cr. @Hwy E	2/18/2015	Grab	<15
550/17.7	No Cr. Nr. Dunlap	2/24/2015	Grab	<15
593/36.0	Grand R. @ Sumner	3/11/2015	Grab	128
550/17.7	No Cr. Nr. Dunlap	3/16/2015	Grab	<30
674/28.8	Mussel Fk. nr. Mystic	3/17/2015	Grab	<30
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/18/2015	Grab	42
623/14.2	L. Medicine Cr. @Hwy E	3/18/2015	Grab	<30
549/49.6	Thompson R. at Mt. Moriah	3/25/2015	Grab	118
560/29.0	Weldon R. nr. Princeton	3/26/2015	Grab	35
550/17.7	No Cr. Nr. Dunlap	4/14/2015	Grab	16
674/28.8	Mussel Fk. nr. Mystic	4/15/2015	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/16/2015	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	4/16/2015	Grab	<15
593/36.0	Grand R. @ Sumner	4/21/2015	Grab	1920
549/49.6	Thompson R. at Mt. Moriah	5/5/2015	Grab	2100
560/29.0	Weldon R. nr. Princeton	5/6/2015	Grab	828
550/17.7	No Cr. Nr. Dunlap	5/11/2015	Grab	218
674/28.8	Mussel Fk. nr. Mystic	5/12/2015	Grab	78
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/13/2015	Grab	34
623/14.2	L. Medicine Cr. @Hwy E	5/13/2015	Grab	23
593/36.0	Grand R. @ Sumner	5/26/2015	Grab	885
550/17.7	No Cr. Nr. Dunlap	6/15/2015	Grab	728

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	6/16/2015	Grab	448
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/17/2015	Grab	263
623/14.2	L. Medicine Cr. @Hwy E	6/17/2015	Grab	101
593/36.0	Grand R. @ Sumner	6/23/2015	Grab	1080
549/49.6	Thompson R. at Mt. Moriah	7/8/2015	Grab	522
560/29.0	Weldon R. nr. Princeton	7/8/2015	Grab	345
593/36.0	Grand R. @ Sumner	7/21/2015	Grab	1640
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/28/2015	Grab	493
623/14.2	L. Medicine Cr. @Hwy E	7/28/2015	Grab	425
674/28.8	Mussel Fk. nr. Mystic	7/29/2015	Grab	2090
550/17.7	No Cr. Nr. Dunlap	7/30/2015	Grab	617
550/17.7	No Cr. Nr. Dunlap	8/10/2015	Grab	453
674/28.8	Mussel Fk. nr. Mystic	8/11/2015	Grab	52
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/12/2015	Grab	172
623/14.2	L. Medicine Cr. @Hwy E	8/12/2015	Grab	122
593/36.0	Grand R. @ Sumner	8/18/2015	Grab	142
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/1/2015	Grab	24
623/14.2	L. Medicine Cr. @Hwy E	9/1/2015	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	9/2/2015	Grab	<15
550/17.7	No Cr. Nr. Dunlap	9/3/2015	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	9/16/2015	Grab	143
560/29.0	Weldon R. nr. Princeton	9/16/2015	Grab	<15
593/36.0	Grand R. @ Sumner	9/16/2015	Grab	148
550/17.7	No Cr. Nr. Dunlap	10/5/2015	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	10/6/2015	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/7/2015	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	10/7/2015	Grab	<15
593/36.0	Grand R. @ Sumner	10/20/2015	Grab	28
549/49.6	Thompson R. at Mt. Moriah	10/28/2015	Grab	132
560/29.0	Weldon R. nr. Princeton	10/28/2015	Grab	117
550/17.7	No Cr. Nr. Dunlap	11/2/2015	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	11/3/2015	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/4/2015	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/4/2015	Grab	<15
593/36.0	Grand R. @ Sumner	11/17/2015	Grab	62
593/36.0	Grand R. @ Sumner	12/2/2015	Grab	438
674/28.8	Mussel Fk. nr. Mystic	12/7/2015	Grab	15
550/17.7	No Cr. Nr. Dunlap	12/8/2015	Grab	26
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/9/2015	Grab	60
623/14.2	L. Medicine Cr. @Hwy E	12/9/2015	Grab	34
560/29.0	Weldon R. nr. Princeton	1/6/2016	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
549/49.6	Thompson R. at Mt. Moriah	1/7/2016	Grab	127
550/17.7	No Cr. Nr. Dunlap	1/11/2016	Grab	46
674/28.8	Mussel Fk. nr. Mystic	1/12/2016	Grab	16
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/13/2016	Grab	43
623/14.2	L. Medicine Cr. @Hwy E	1/13/2016	Grab	52
593/36.0	Grand R. @ Sumner	1/26/2016	Grab	109
593/36.0	Grand R. @ Sumner	2/22/2016	Grab	648
549/49.6	Thompson R. at Mt. Moriah	3/2/2016	Grab	106
560/29.0	Weldon R. nr. Princeton	3/2/2016	Grab	90
674/28.8	Mussel Fk. nr. Mystic	3/8/2016	Grab	30
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/9/2016	Grab	277
623/14.2	L. Medicine Cr. @Hwy E	3/9/2016	Grab	1020
550/17.7	No Cr. Nr. Dunlap	3/10/2016	Grab	102
593/36.0	Grand R. @ Sumner	3/14/2016	Grab	350
593/36.0	Grand R. @ Sumner	4/5/2016	Grab	135
674/28.8	Mussel Fk. nr. Mystic	4/5/2016	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/6/2016	Grab	30
623/14.2	L. Medicine Cr. @Hwy E	4/6/2016	Grab	39
550/17.7	No Cr. Nr. Dunlap	4/7/2016	Grab	26
549/49.6	Thompson R. at Mt. Moriah	5/5/2016	Grab	820
560/29.0	Weldon R. nr. Princeton	5/5/2016	Grab	125
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/17/2016	Grab	77
623/14.2	L. Medicine Cr. @Hwy E	5/17/2016	Grab	46
674/28.8	Mussel Fk. nr. Mystic	5/18/2016	Grab	25
550/17.7	No Cr. Nr. Dunlap	5/19/2016	Grab	<15
593/36.0	Grand R. @ Sumner	5/24/2016	Grab	91
593/36.0	Grand R. @ Sumner	6/7/2016	Grab	300
550/17.7	No Cr. Nr. Dunlap	6/21/2016	Grab	558
674/28.8	Mussel Fk. nr. Mystic	6/22/2016	Grab	150
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/23/2016	Grab	40
623/14.2	L. Medicine Cr. @Hwy E	6/23/2016	Grab	67
560/29.0	Weldon R. nr. Princeton	7/7/2016	Grab	115
549/49.6	Thompson R. at Mt. Moriah	7/8/2016	Grab	78
550/17.7	No Cr. Nr. Dunlap	7/19/2016	Grab	16
593/36.0	Grand R. @ Sumner	7/19/2016	Grab	48
623/14.2	L. Medicine Cr. @Hwy E	7/19/2016	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	7/20/2016	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/21/2016	Grab	51
593/36.0	Grand R. @ Sumner	8/2/2016	Grab	648
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/23/2016	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	8/23/2016	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	8/24/2016	Grab	<15
550/17.7	No Cr. Nr. Dunlap	8/25/2016	Grab	216
560/29.0	Weldon R. nr. Princeton	9/13/2016	Grab	27
593/36.0	Grand R. @ Sumner	9/13/2016	Grab	416
549/49.6	Thompson R. at Mt. Moriah	9/14/2016	Grab	114
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/20/2016	Grab	532
623/14.2	L. Medicine Cr. @Hwy E	9/20/2016	Grab	800
674/28.8	Mussel Fk. nr. Mystic	9/21/2016	Grab	65
550/17.7	No Cr. Nr. Dunlap	9/22/2016	Grab	57
549/49.6	Thompson R. at Mt. Moriah	10/5/2016	Grab	78
560/29.0	Weldon R. nr. Princeton	10/5/2016	Grab	<15
550/17.7	No Cr. Nr. Dunlap	10/17/2016	Grab	<15
593/36.0	Grand R. @ Sumner	10/18/2016	Grab	29
674/28.8	Mussel Fk. nr. Mystic	10/18/2016	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/19/2016	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	10/19/2016	Grab	<15
550/17.7	No Cr. Nr. Dunlap	11/1/2016	Grab	19
623/14.2	L. Medicine Cr. @Hwy E	11/1/2016	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/2/2016	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	11/3/2016	Grab	25
593/36.0	Grand R. @ Sumner	11/8/2016	Grab	<15
550/17.7	No Cr. Nr. Dunlap	12/5/2016	Grab	<25
593/36.0	Grand R. @ Sumner	12/6/2016	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	12/6/2016	Grab	<21
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/7/2016	Grab	<21
623/14.2	L. Medicine Cr. @Hwy E	12/7/2016	Grab	<21
593/36.0	Grand R. @ Sumner	1/10/2017	Grab	<15
560/29.0	Weldon R. nr. Princeton	1/11/2017	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	1/12/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/24/2017	Grab	34
623/14.2	L. Medicine Cr. @Hwy E	1/24/2017	Grab	27
674/28.8	Mussel Fk. nr. Mystic	1/25/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	1/26/2017	Grab	<15
593/36.0	Grand R. @ Sumner	2/6/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/7/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	2/7/2017	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	2/8/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	2/9/2017	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	3/8/2017	Grab	21
560/29.0	Weldon R. nr. Princeton	3/9/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	3/14/2017	Grab	15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	3/15/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/16/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	3/16/2017	Grab	<15
593/36.0	Grand R. @ Sumner	3/20/2017	Grab	41
593/36.0	Grand R. @ Sumner	4/4/2017	Grab	1510
550/17.7	No Cr. Nr. Dunlap	4/11/2017	Grab	310
674/28.8	Mussel Fk. nr. Mystic	4/12/2017	Grab	52
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/13/2017	Grab	125
623/14.2	L. Medicine Cr. @Hwy E	4/13/2017	Grab	80
560/29.0	Weldon R. nr. Princeton	5/10/2017	Grab	52
549/49.6	Thompson R. at Mt. Moriah	5/11/2017	Grab	1440
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/16/2017	Grab	33
623/14.2	L. Medicine Cr. @Hwy E	5/16/2017	Grab	27
674/28.8	Mussel Fk. nr. Mystic	5/17/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	5/18/2017	Grab	36
593/36.0	Grand R. @ Sumner	6/6/2017	Grab	47
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/6/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	6/6/2017	Grab	59
674/28.8	Mussel Fk. nr. Mystic	6/7/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	6/8/2017	Grab	17
593/36.0	Grand R. @ Sumner	6/27/2017	Grab	64
550/17.7	No Cr. Nr. Dunlap	7/11/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	7/11/2017	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	7/12/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/13/2017	Grab	47
560/29.0	Weldon R. nr. Princeton	7/19/2017	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	7/20/2017	Grab	33
593/36.0	Grand R. @ Sumner	7/25/2017	Grab	90
550/17.7	No Cr. Nr. Dunlap	8/8/2017	Grab	41
593/36.0	Grand R. @ Sumner	8/8/2017	Grab	58
623/14.2	L. Medicine Cr. @Hwy E	8/8/2017	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	8/9/2017	Grab	76
619/15.6	E. Fk. Medicine Cr. nr. Harris	8/10/2017	Grab	<15
593/36.0	Grand R. @ Sumner	9/12/2017	Grab	71
549/49.6	Thompson R. at Mt. Moriah	9/20/2017	Grab	164
560/29.0	Weldon R. nr. Princeton	9/21/2017	Grab	18
550/17.7	No Cr. Nr. Dunlap	9/26/2017	Grab	36
623/14.2	L. Medicine Cr. @Hwy E	9/26/2017	Grab	20
674/28.8	Mussel Fk. nr. Mystic	9/27/2017	Grab	32
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/28/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	10/3/2017	Grab	<15

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
623/14.2	L. Medicine Cr. @Hwy E	10/3/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	10/5/2017	Grab	<15
593/36.0	Grand R. @ Sumner	10/16/2017	Grab	60
560/29.0	Weldon R. nr. Princeton	10/18/2017	Grab	17
549/49.6	Thompson R. at Mt. Moriah	10/19/2017	Grab	198
593/36.0	Grand R. @ Sumner	11/7/2017	Grab	24
550/17.7	No Cr. Nr. Dunlap	11/27/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	11/28/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	11/28/2017	Grab	18
593/36.0	Grand R. @ Sumner	12/5/2017	Grab	<15
550/17.7	No Cr. Nr. Dunlap	12/18/2017	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	12/19/2017	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	12/19/2017	Grab	<15
549/49.6	Thompson R. at Mt. Moriah	1/9/2018	Grab	<15
560/29.0	Weldon R. nr. Princeton	1/9/2018	Grab	<15
593/36.0	Grand R. @ Sumner	1/9/2018	Grab	<15
550/17.7	No Cr. Nr. Dunlap	1/23/2018	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	1/24/2018	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	1/24/2018	Grab	<15
550/17.7	No Cr. Nr. Dunlap	2/13/2018	Grab	<15
593/36.0	Grand R. @ Sumner	2/13/2018	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	2/13/2018	Grab	,15
619/15.6	E. Fk. Medicine Cr. nr. Harris	2/14/2018	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	2/15/2018	Grab	<15
560/29.0	Weldon R. nr. Princeton	3/7/2018	Grab	44
549/49.6	Thompson R. at Mt. Moriah	3/8/2018	Grab	46
550/17.7	No Cr. Nr. Dunlap	3/13/2018	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	3/14/2018	Grab	16
619/15.6	E. Fk. Medicine Cr. nr. Harris	3/15/2018	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	3/15/2018	Grab	<15
593/36.0	Grand R. @ Sumner	3/27/2018	Grab	46
674/28.8	Mussel Fk. nr. Mystic	4/11/2018	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	4/12/2018	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	4/12/2018	Grab	<15
550/17.7	No Cr. Nr. Dunlap	4/13/2018	Grab	<15
593/36.0	Grand R. @ Sumner	4/26/2018	Grab	25
593/36.0	Grand R. @ Sumner	5/8/2018	Grab	272
560/29.0	Weldon R. nr. Princeton	5/9/2018	Grab	23
549/49.6	Thompson R. at Mt. Moriah	5/10/2018	Grab	193
550/17.7	No Cr. Nr. Dunlap	5/15/2018	Grab	278
623/14.2	L. Medicine Cr. @Hwy E	5/15/2018	Grab	27

Site Code	Site Name	Date	Sample Type	TSS (mg/L)
674/28.8	Mussel Fk. nr. Mystic	5/16/2018	Grab	426
619/15.6	E. Fk. Medicine Cr. nr. Harris	5/17/2018	Grab	32
550/17.7	No Cr. Nr. Dunlap	6/4/2018	Grab	<15
674/28.8	Mussel Fk. nr. Mystic	6/5/2018	Grab	70
593/36.0	Grand R. @ Sumner	6/6/2018	FieldDupl	268
619/15.6	E. Fk. Medicine Cr. nr. Harris	6/6/2018	Grab	25
623/14.2	L. Medicine Cr. @Hwy E	6/6/2018	Grab	25
593/36.0	Grand R. @ Sumner	7/9/2018	Grab	69
549/49.6	Thompson R. at Mt. Moriah	7/11/2018	Grab	142
560/29.0	Weldon R. nr. Princeton	7/11/2018	Grab	19
550/6.2	No Cr. @ Farmersville, Mo nr Hwy 65	7/25/2018	Grab	208
606/20.6	Locust Cr. @ Calico Rd.	7/25/2018	Grab	<15
619/15.6	E. Fk. Medicine Cr. nr. Harris	7/26/2018	Grab	<15
623/14.2	L. Medicine Cr. @Hwy E	7/26/2018	Grab	17
593/36.0	Grand R. @ Sumner	8/7/2018	Grab	56
593/36.0	Grand R. @ Sumner	8/31/2018	Grab	165
593/36.0	Grand R. @ Sumner	9/1/2018	Grab	313
593/36.0	Grand R. @ Sumner	9/4/2018	Grab	1810
560/29.0	Weldon R. nr. Princeton	9/6/2018	Grab	2080
549/49.6	Thompson R. at Mt. Moriah	9/7/2018	Grab	1490
550/17.7	No Cr. Nr. Dunlap	9/18/2018	Grab	23
619/15.6	E. Fk. Medicine Cr. nr. Harris	9/18/2018	Grab	<15
593/36.0	Grand R. @ Sumner	9/19/2018	Grab	62
674/28.8	Mussel Fk. nr. Mystic	9/19/2018	Grab	33
623/14.2	L. Medicine Cr. @Hwy E	9/20/2018	Grab	71
560/29.0	Weldon R. nr. Princeton	10/3/2018	Grab	16
549/49.6	Thompson R. at Mt. Moriah	10/4/2018	Grab	129

References

USGS (U.S. Geological Survey). 2010. Use of Continuous Monitors and Autosamplers to Predict Unmeasured Water-Quality Constituents in Tributaries of the Tualatin River, Oregon. https://pubs.usgs.gov/sir/2010/5008/pdf/sir20105008.pdf

USGS (U.S. Geological Survey). 2013. Comparison Between Two Statistically Based Methods, and Two Physically Based Models Developed to Computer Daily Mean Streamflow at Ungaged Locations in the Cedar River Basin, Iowa. https://pubs.usgs.gov/sir/2013/5111/sir13_5111_web.pdf